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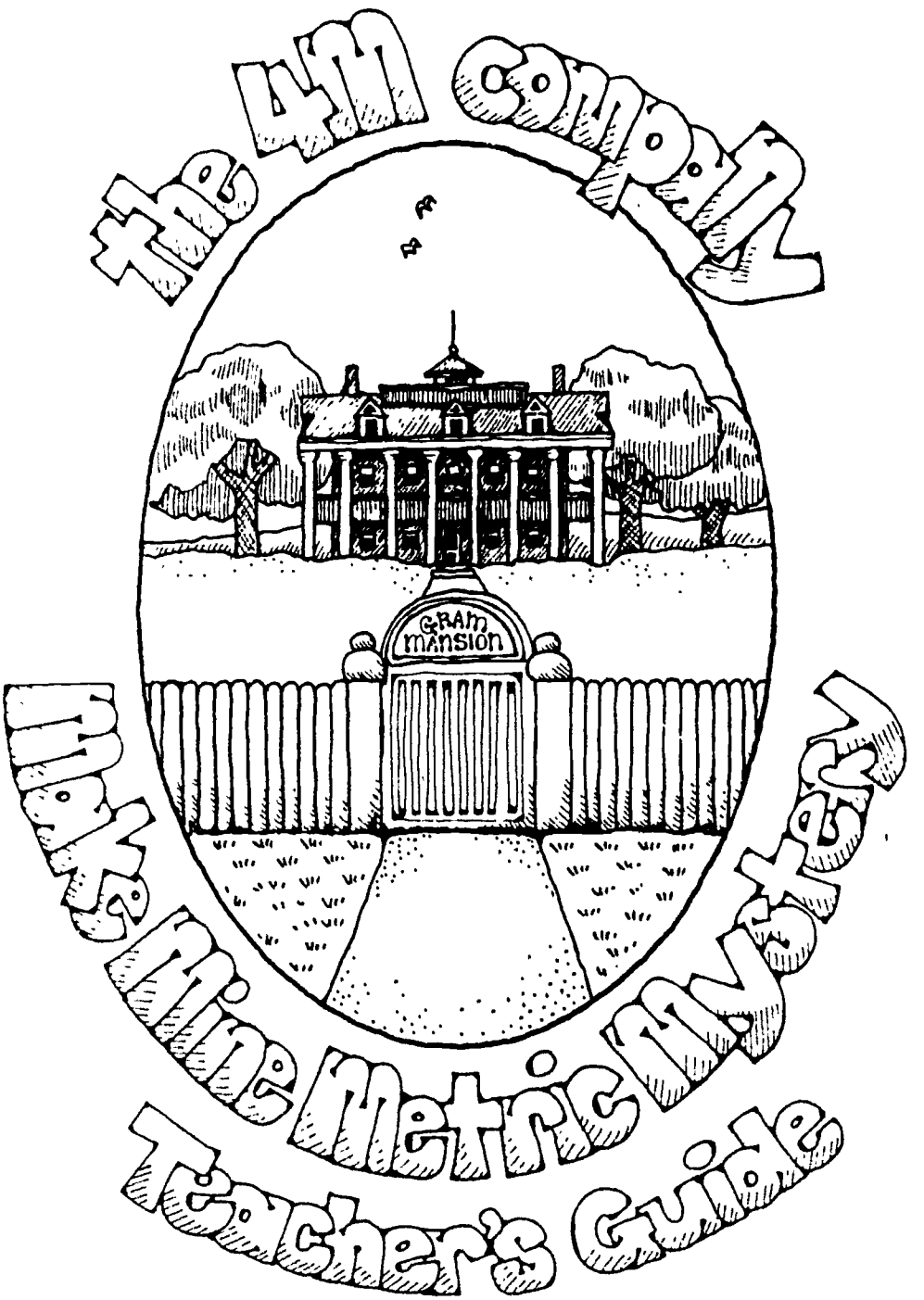
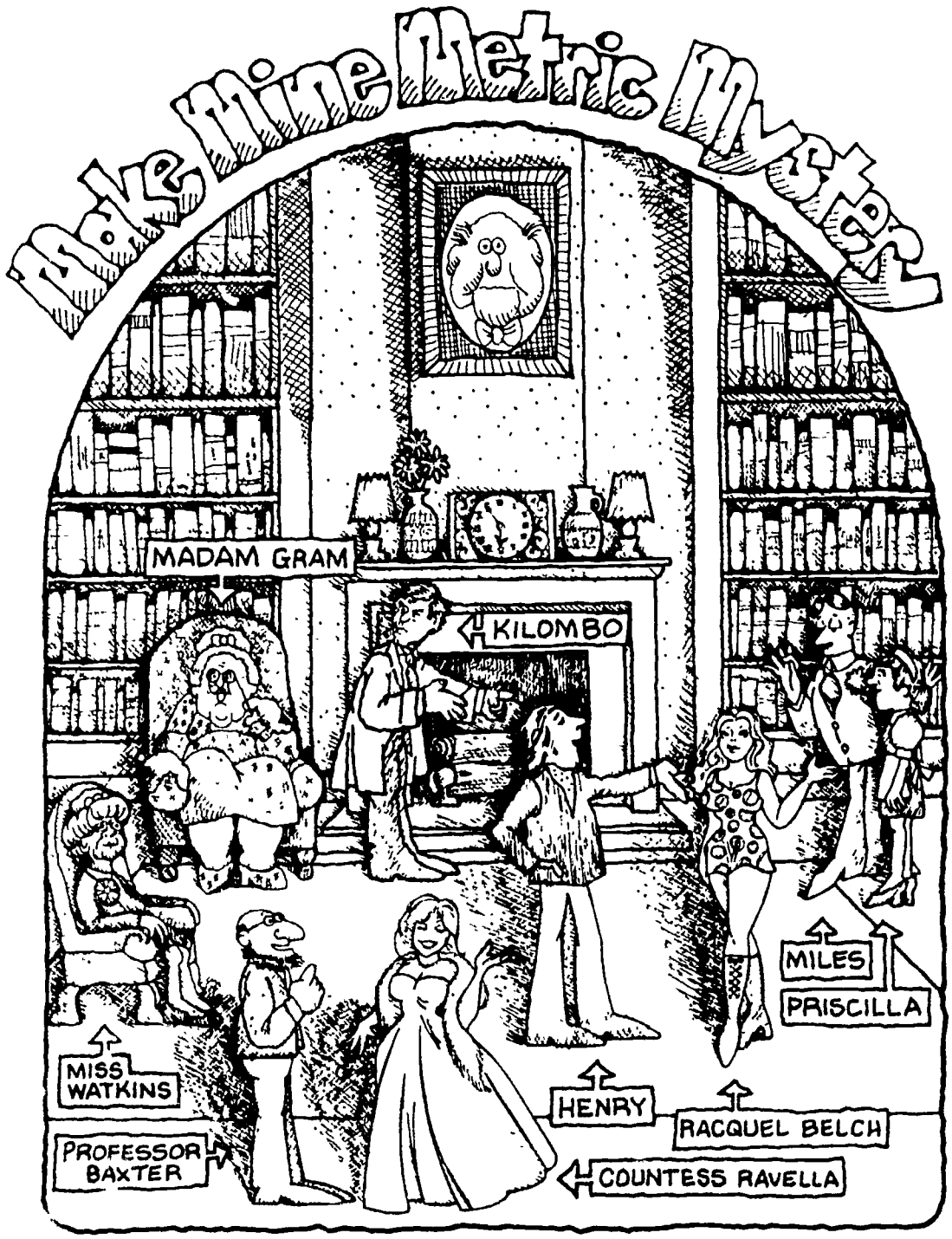
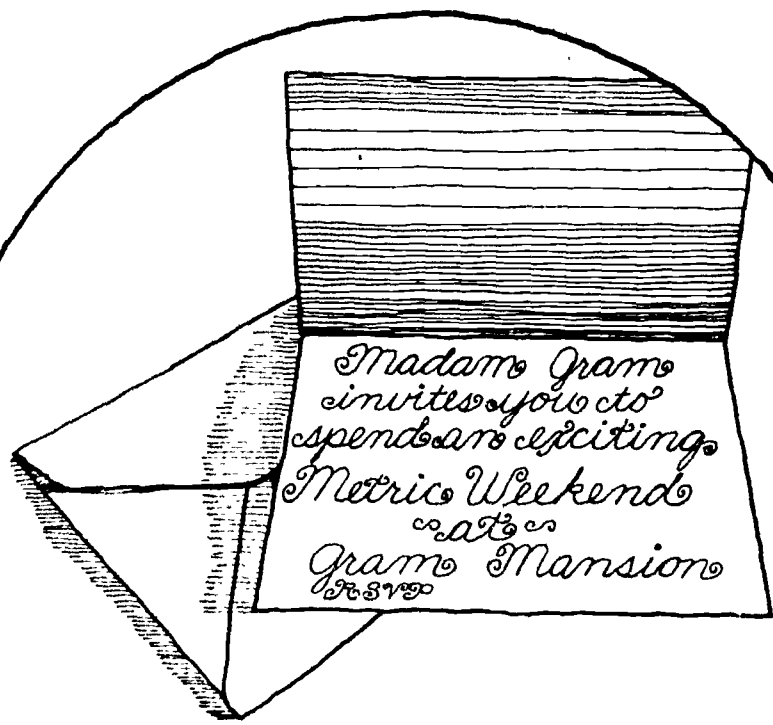
ABSTRACT

This is one of several teacher's guides for the 4M Company, a set of materials for teaching metric concepts and computation skills to elementary school students. Included in this guide are sections on needed materials, metric prefixes and symbols, length, decimals, perimeter, area, volume, mass, temperature, and a minicourse on metrics. Answers to the activities in the related student activity manual are included. (RH)




Make Mine Metric Mystery
MADAM GRAM
KILOMBO
MILES
PRISCILLA
MISS WATKINS
HENRY
RACQUEL BELCH
PROFESSOR BAXTER
COUNTESS RAVELLA



WELCOME TO GRAM MANSION THE HOME OF THE FABULOUSLY WEALTHY MADAM GRAM. MADAM GRAM HAS AN INTERESTING HOBBY—THE METRIC SYSTEM—AND SHE HAS INVITED A GROUP OF FRIENDS TO SPEND A METRIC WEEKEND AT HER FANCY MANSION IN BEVERLY HILLS.

THE GUESTS INCLUDE: PROFESSOR BAXTER, A COLLEGE PROFESSOR; LITTLE MISS WATKINS, AN OLD MAID; COUNTESS RAVELLA, A BEAUTIFUL HEIRESS TO A LARGE FORTUNE; HENRY, MADAM GRAM'S PLAYBOY NEPHEW; RACQUEL BELCH, A GLAMOROUS MOVIE STAR; INSPECTOR KILOMBO, A FAMOUS T.V. DETECTIVE; AND YOU! PRISCILLA THE MAID, AND HER HUSBAND MILES, THE BUTLER, ROUND OUT OUR CAST OF CHARACTERS.

OUR MYSTERY BEGINS ON FRIDAY EVENING. ALL THE GUESTS HAVE ARRIVED AND HAVE ASSEMBLED IN THE LIBRARY...

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to the teacher

Curriculum materials are only one of the factors involved in the learning process. No program can anticipate the other factors - your unique characteristics as a teacher, the characteristics of your students, and your classroom situation. Yet these factors must all be considered for a successful learning experience. It is you, the teacher, who must analyze these factors to make decisions and adjustments in the learning activities as described in this Teacher's Guide.

The 4M COMPANY provides a variety of classroom organizations: at times students will work as an entire class, at times they will work in small groups, and at times they will work alone. Depending on the unique combination of factors which make up your classroom, the procedures recommended in this Teacher's Guide may or may not work in your particular classroom. Feel free to adapt the program to meet your particular needs. Following the Teacher's Guide word-for-word is not important; learning the objectives of the program is!

You are a unique person, and no one will teach The 4M COMPANY exactly as you do. Your strengths, your weaknesses, your abilities, and your overall philosophy will influence your teaching. Keep in mind, however, the following roles which you must play as a teacher.

The role of a planner. The 4M COMPANY is an activity program, and you will be required to prepare materials for most lessons. Things will not always work out as you had planned, so be prepared to alter your plans if the need arises.

The role of a demonstrator. Although this Teacher's Guide outlines one approach to teaching the objectives of a lesson, you must decide if a given demonstration is working with your students. They are unique, and you may have to alter the demonstration to meet their level of understanding.

The role of a questioner. Instead of always giving answers, ask the children remedial questions that will clarify their thinking. Ask more difficult questions of children who need more challenge.

The role of a motivator. No student can be made to learn if he doesn't want to. The 4M COMPANY has tried to motivate children in several ways - the cartoon format of the booklets, the use of a story line for each grade level, and the use of games and activities. But in addition to our efforts, you will still need to motivate and encourage children to learn.

The role of a summarizer. At the conclusion of an activity, you encourage students to share their findings. It is important to summarize the results of each activity.

We have tried to make The 4M COMPANY an enjoyable and effective metric program. To a large extent your attitude will determine the success of the program. If you are unfamiliar with parts of the metric system, admit this to yourself and to your students. If you adopt a positive attitude of learning with your students, this will do much to create a good classroom environment. For ready reference, the Appendix to this Teacher's Guide contains a brief review of the metric system.

The following paragraphs deal specifically with this level of THE 4M COMPANY. Please read them carefully.

content

At this level of THE 4M COMPANY students briefly compare the English and metric systems of measurement. The systematic and logical relationships of the metric units are presented. In exploring the concepts of length, perimeter, area, volume, capacity, mass (weight), and temperature, students are exposed to the following metric units: the meter and its multiples and submultiples, the liter and its multiples and submultiples, the gram and its multiples and submultiples, mm^2, cm^2, dm^2, m^2, km^2, cm^3, dm^3, m^3, and degrees Celsius. Students review decimals and add and subtract one-, two-, and three-place decimals using a metric length model. Using a metric area model, students multiply and divide one-, two-, and three-place decimals by one digit whole numbers. Repeated references to the chart of the metric units helps reinforce the structure of the metric system and the spellings and meanings of the prefixes and units.

decimals

In The 4M company the base ten nature of the metric system is used to review the concept of decimal fractions. A decimeter is 0.1 meter, a centimeter is 0.01 meter, and a millimeter is 0.001 meter. The emphasis is on measuring with standard instruments (rulers, tapes, graduated cylinders) and recording in decimal form (to the nearest hundredth of a meter, thousandth of a meter, thousandth of a liter). A complete understanding of place value is not expected at this level.

zero

In writing decimal expressions less than 1.0, it is now recommended that a zero be placed in the ones' place. For example, 0.3 meters is recommended instead of .3 meters. This convention is practiced worldwide. The use of the zero has two main advantages: 1) If the decimal point is light, or somehow erased, it is immediately evident that the point is missing. For example, 03 means three tenths, or 0.3; 2) In teaching children it helps us distinguish the fractional parts from the whole parts. For example, in the expression .27, some children might think that the 7 is in the ones' place and the 2 in the tens' place. By placing a zero in the ones' place this confusion might be avoided.

estimating

Throughout the program children should be encouraged to estimate before measuring. Encourage careful measuring, but explain that no measure is exact. Use the words "about" or "almost" to describe inexact measurements.

reinforcement

Experience has shown that retention of metric concepts and vocabulary will occur only if they are reinforced throughout the school year. Make a flashcard for each metric unit and another for its symbol. Use these frequently to reinforce metric vocabulary. It is also a good idea to set metric units in front of the class and have them identify the various units by name. Familiarity with the units is a major goal of the program, and this can be achieved by frequent drill and review.

computation

At this level of THE 4M COMPANY computation with decimals is presented using a length model as the rationale for addition and subtraction and an area model for multiplication and division. It is expected that the basic operation algorithms will be taught in the regular math program. The work in this program will reinforce these skills and extend them to include operations with one-, two-, and three-place decimals, using measurement concepts as a rationale for the steps of the computational algorithms.

rounding off

Measurement provides an easy, visual model for teaching students how to round off; the measurement is rounded off to the nearest unit by merely looking at the measuring instrument. Explain that the measurement is rounded down if the fractional part is less than half a unit and rounded up if the fractional part is half a unit or more.

metric chart

It is recommended that each classroom have a chart of the metric system. Put one up early in the year and as each metric unit is introduced, point it out on the chart. Page 48 in this Teacher's Guide may be used to make a colorful poster where each unit can be highlighted with color when it is introduced. The page may be removed, used to make an overhead transparency, and the overhead projector used to enlarge the chart onto a piece of poster board where it can be traced and colored. An opaque projector may be used to accomplish the same thing using the page directly.

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materials

1	a demonstration meter stick or a mm ruler, cm ruler, dm ruler, and a meter stick; gram, dag, hg, and kg weights
2	index cards to make playing cards and flashcards
3	meter sticks, cm rulers, mm rulers
4	long measuring tape marked in meters and cm, cm rulers, mm rulers
5	tape measure marked in meters and mm, adding machine tape
6	masking tape, tape measure or meter stick marked in cm
7	masking tape, several dm^2 and cm^2, cm rulers
8	masking tape
9	none
10	a liter container, graduated cylinder, an assortment of small containers, 10 quarters, water, 10 index cards to make card game (activity #6)
11	unit cubes, boxes
12	unit cubes, cubic centimeters, (plastic) cubic decimeter, 12 meter sticks to make a cubic meter (optional), liter measure, water
13	2-pan balance, metric weights, bathroom scale, tape measures, 2 meter sticks, liter container, water, kilogram weight; a pencil, a ballpoint pen, a chalkboard eraser, a glass with some water in it, and a metric booklet; 10 index cards to make card game (activity #6); vitamin bottle or cereal box with mg on it
14	Celsius thermometers, ice water, boiling water (if available)
15	none

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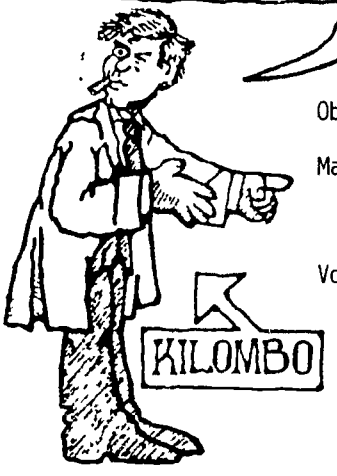
section 1 · introduction to the metric system



Objectives: None (See statement of purpose below.)

Materials: a demonstration meter stick or a mm ruler, cm ruler, dm ruler, and a meter stick; gram, dag, hg, and kg weights

Vocabulary: meter, liter, gram, prefix, kilo-, hecto-, deka-, deci-, centi-, milli-, all prefix and unit combinations

SUGGESTED PROCEDURE AND ACTIVITIES:

This section has two purposes: 1) to present a rationale for the United States' conversion to the metric system of measurement, and 2) to present students with an overview of what they will be studying.

1. Explain that the United States is in the process of converting to the metric system of measurement. All other industrialized nations of the world use the metric system except us. Explain that this puts the United States at a disadvantage in world trade. It makes some of our products undesirable because parts cannot be replaced easily, and we have to convert all of our measurements to determine costs and make payments. This is one reason the United States is converting to the metric system. There are other reasons and these will become apparent as students proceed.

2. Have students examine the title of their metric booklets and see if anyone can discover that THE 4M COMPANY title is derived from the four "M's" in the Make Mine Metric Mystery. Read the story line together then proceed to page 1.

3. Page 1 contains basic relationships for both English and metric units of length. Read these aloud and ask students to make comparisons. Each metric unit is 10 times larger than the next smaller unit. There is no regular relationship between English units. Explain that this is one of the great advantages of the metric system over the English System and a major reason for converting to the metric system.

4. Page 2 contains a table which illustrates the basic relationships in the metric system. Hold up a meter and explain that it is the main unit for measuring length. All other units of length are formed by adding a prefix to the word meter. Point out that

all units for length contain the word "meter."

Use rulers or a demonstration meter stick to compare mm, cm, dm, and m. Point out that each unit is ten times larger than the next smaller unit. There are 1000 mm in a meter, 100 cm in a meter, and 10 dm in a meter.

Repeat the explanation with the liter and the gram. Compare the gram, dag, hg, and kg, letting students feel their comparative weights.

Be sure to point out that each prefix has a fixed value and always keeps that value. Thus, a kilometer is 1000 meters, a kiloliter is 1000 liters, and a kilogram is 1000 grams.

This use of prefixes with a basic unit and the fact that units are all related by tens make the metric system a better system than our present one and will make it easy to learn.

5. Quiz the students on the use of the table on page 2. "A kilometer is how many meters?" "0.1 liters is called a . . . " Have students pose similar questions for the rest of the class.

6. Have the students look through their booklets to get an idea of what lies ahead.

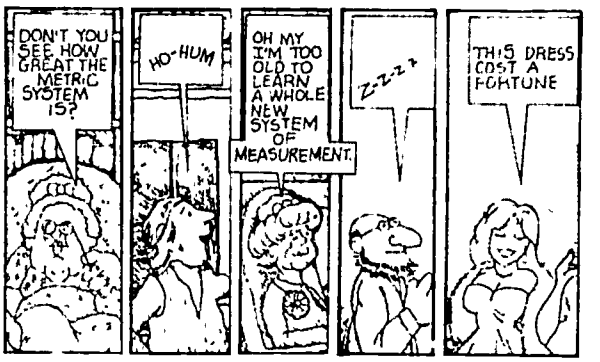
ENGLISH SYSTEM

12 inches	→	1 foot
3 feet	→	1 yard
5½ yards	→	1 rod
40 rods	→	1 furlong
8 furlongs	→	1 mile
3 miles	→	1 league

METRIC SYSTEM

10 millimeters	→	1 centimeter
10 centimeters	→	1 decimeter
10 decimeters	→	1 meter
10 meters	→	1 dekameter
10 dekameters	→	1 hectometer
10 hectometers	→	1 kilometer

1



	length	capacity	weight (mass)
1000	kilometer	kiloliter	kilogram
100	hectometer	hectoliter	hectogram
10	dekameter	dekaliter	dekagram
1	meter	liter	gram
0.1	decimeter	deciliter	decigram
0.01	centimeter	centiliter	centigram
0.001	millimeter	milliliter	milligram

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section 2. metric prefixes and symbols

Objectives: Given the name of a common metric unit, spell it.

Given the six common metric prefixes, write their numerical values.

Given a metric unit, write the corresponding symbol.

Given a metric symbol, write the corresponding unit.

Materials: index cards to make playing cards and flashcards

Vocabulary: metre, litre, km, hm, dam, m, dm, cm, mm, kL, hL, daL, L, dL, cL, mL, kg, hg, dag, g, dg, cg, mg

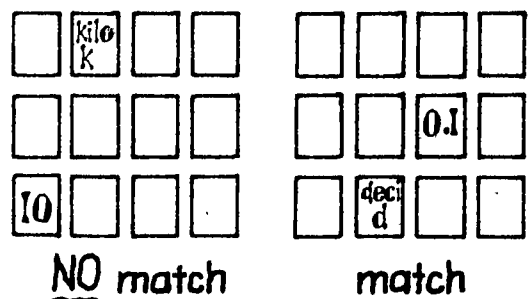
SUGGESTED PROCEDURE AND ACTIVITIES:

1. There are two acceptable ways to spell "meter" and "liter", the other spellings being "metre" and "litre". THE 4M COMPANY uses the "er", but your students should be aware that "re" is also acceptable.

   Learning to spell the 21 common metric units can be accomplished though drill and practice. Students can work in pairs to quiz each other. Spelling is a basic part of "metric literacy".

2. Return to the chart on page 2 and explain the meanings of the six prefixes. Students should memorize the values of all six.

3. To help students learn these six prefixes, let them play metric concentration. Each deck has 12 cards, which can be cut from index cards or construction paper (4cm x 5cm). The six prefixes are written on six of the cards, their corresponding values are written on the other six. The game is played by two players. The cards are shuffled and laid face down. The first player turns any two cards face up, one at a time. If they match - for example, kilo and 1000 - he picks up the cards. If not, he turns them over again. The second player then turns two cards face up, one at a time. The object of the game is to pick up, i.e. match, the most cards. Play continues until all cards have been picked up.



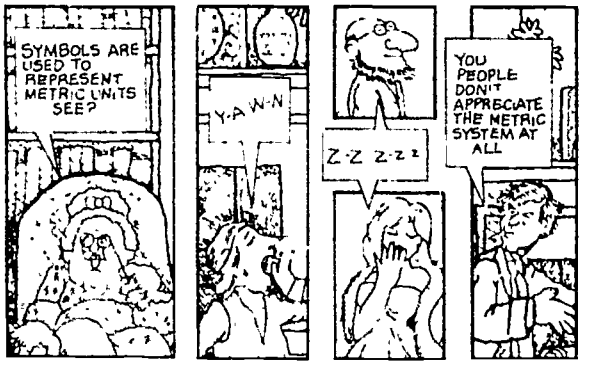
4. Flash cards can also be made from index cards. Write the

prefix on one side, its value on the other. Students can then quiz themselves, or each other.

5. Point out that symbols are used to represent metric units. This saves us the trouble of always having to write out the entire word each time we use a unit.

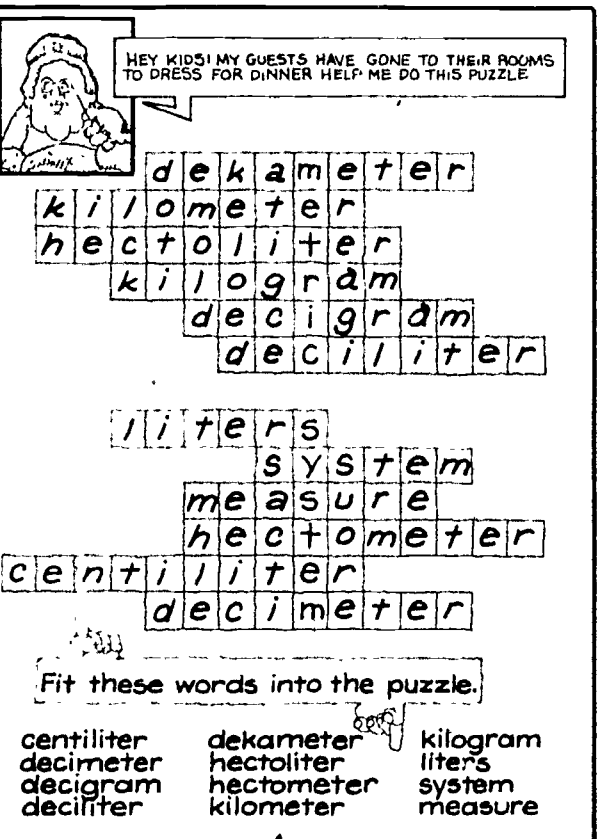
   Explain the symbols in the chart on page 3. Ask students to provide the corresponding units. Students can drill each other, or flash cards can be used. Knowing the correct symbols will help students in the work which follows.

6. Page 4 provides further experience with metric words.



	length	capacity	weight (mass)
1000	km	kL	kg
100	hm	hL	hg
10	dam	daL	dag
1	m	L	g
0.1	dm	dL	dg
0.01	cm	cL	cg
0.001	mm	mL	mg

3



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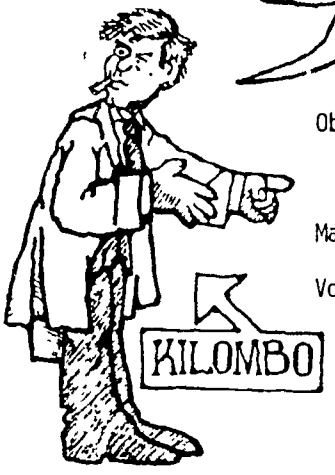
section 3 · length



Objective: Given a meter stick, centimeter ruler, or millimeter ruler, determine the length of an object to the nearest unit.

Materials: meter sticks, cm rulers, mm rulers

Vocabulary: meter, decimeter, centimeter, millimeter, kilometer

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Introduce the meter as the main unit of length in the metric system. Have the class estimate the distance from the classroom to some object (tree, rock, etc.). Then have a group of students measure the distance. See who came the closest to the actual measure.

2. Use the chart on page 1 or 2 to point out other units of length. The meter is divided into 10 equal parts called decimeters, 100 equal parts called centimeters, and 1000 equal parts called millimeters. Since the decimeter is not used in daily living, the students will measure with only the centimeter and millimeter.

3. Assign pages 5 and 6. Write two expressions on the board (15 cm and 25 mm). See who can find objects in the classroom having these precise lengths.

4. On page 7 students can measure any 7 things they choose.

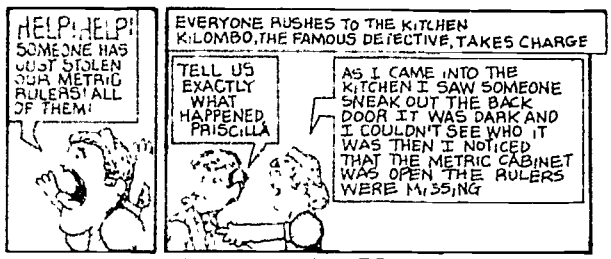
5. Explain that for distances much longer than a meter, like the distance between towns, the kilometer is used. One kilometer is 1000 meters. It is about the distance you can walk in fifteen minutes, without stopping. Dekameters and hectometers are rarely used in daily life.

   The charts on pages 8 and 9 give distances between various places on Hawaii and Kauai. Explain how to use the tables. For example, by following the Akaka Falls column down and the Volcano House row across we find that it is 72 kilometers from Akaka Falls to the Volcano House. Do some examples orally then have students use the charts to complete the questions at the bottom of each page.

6. On page 10 students are to name

each island. They may have to refer to a map or an encyclopedia.

7. Each week pose a "metric challenge". Select a length or distance in the classroom for everyone to estimate in meters, centimeters, or millimeters. Write the estimates on the board, then take the actual measure. See whose estimate was closest. You might keep a sack of hard candies to award as the prize for the closest estimate in periodic "metric challenges".



Hey kids, you still have your rulers! Measure these in centimeters.

7 cm

3 cm

5 cm

10 cm

12 cm

5

If your metric ruler isn't missing measure these in millimeters.

52 mm

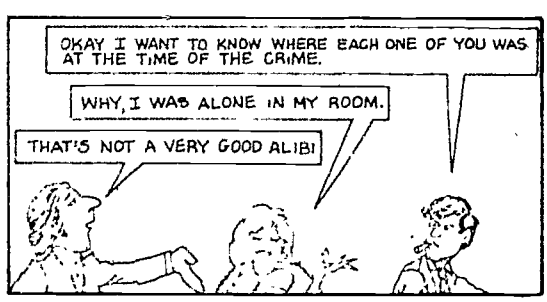
29 mm

68 mm

40 mm

115 mm

6



Choose 7 things to measure.

name of thing	its length
1.	
2.	
3.	
4.	
5.	
6.	
7.	

7

Distances in kilometers on HAWAII

Akaka Falls	City of Refuge	Hilo	Kailua	Kalapana (Black Sand Beach)	Volcano House	Waimea
163						
24	187					
130	34	163				
74	237	59	203			
72	117	144	147	53		
80	94	101	62	139	139	

Akaka Falls to Kailua 130 km
Volcano House to Hilo 144 km
Waimea to City of Refuge 94 km
Kalapana to Hilo 59 km
City of Refuge to Waimea 94 km

8

Distances in Kilometers on KAUAI

Haena	Hanapepe	Kokee	Lihue	Waimea
93				
131	38			
64	29	67		
102	10	29	38	

Lihue to Hanapepe 29 km
Haena to Waimea 102 km
Kokee to Haena 131 km
Hanapepe to Waimea 10 km
Lihue to Kokee 67 km

9

The Hawaiian Islands

Name each island.

1. Niihau
2. Kauai
3. Oahu
4. Molokai
5. Maui
6. Lanai
7. Hawaii

Tell how far it is from...

Kona to Oahu 272 km
Molokai to Maui 77 km
Maui to Lanai 54 km
Oahu to Kauai 163 km

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section 4. decimals: measuring and writing

Objectives: Given a centimeter ruler, measure and record lengths correct to the nearest hundredth of a meter.

Given a millimeter ruler, measure and record lengths correct to the nearest thousandth meter.

Materials: long measuring tape marked in meters and cm, cm rulers, mm rulers

Vocabulary: decimal, decimal point, tenths of a meter, hundredths of a meter, thousandths of a meter

SUGGESTED PROCEDURE AND ACTIVITIES:

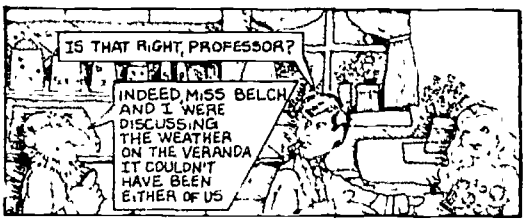
1. In the English system of measurement units are frequently mixed. For example, 3 feet 2 inches, 4 pounds 6 ounces, etc. With metric, it is recommended that units not be mixed. Therefore, decimals are frequently encountered.

   Illustrate this by measuring the length of the chalkboard (or anything else that is more than one meter long) with a measuring tape marked in cm. Suppose it is 2 m 32 cm long. Explain that since cm are hundredths of a meter, we express this length as 2.32 m -- two and thirty-two hundredths of a meter. Do several examples on the board, then assign page 11. When completed, check the answers, especially exercises 4 and 6.

2. On page 12 students are to work in small groups. They choose 7 objects to measure using centimeter rulers, then write the name of the object and its length (in decimal form) in their booklets.

3. When more precise measurements are required, millimeters are used. Such measures are written as thousandths of a meter. Measure an object to the nearest millimeter, and express it on the chalkboard as a decimal.

4. Assign pages 13 and 14. Items 4, 5, 6, and 7 on page 13 might cause difficulty. On page 14 students are to work in small groups again. They choose 7 objects to measure using a millimeter ruler, then write the name of the object and its length (in decimal form) in their booklets.



Express as meters.

1. 2m and 75 cm 2.75 m
2. 5m and 47 cm 5.47 m
3. 9m and 15 cm 9.15 m
4. 8m and 6 cm 8.06 m
5. 45m and 38 cm 45.38 m
6. 4m and 9 cm 4.09 m
7. 0m and 79 cm 0.79 m
8. 14m and 24 cm 14.24 m
9. 27m and 51 cm 27.51 m
10. 67m and 62 cm 67.62 m

11

Measure seven things. Record to the nearest hundredth of a meter.

	object	length
1.		
2.		
3.		
4.		
5.		
6.		
7.		

12

Express as meters.

1. 10m and 273 mm 10.273 m
2. 14m and 495 mm 14.495 m
3. 27m and 607 mm 27.607 m
4. 8m and 27 mm 8.027 m
5. 1m and 7 mm 1.007 m
6. 6m and 19 mm 6.019 m
7. 45m and 103 mm 45.103 m
8. 8m and 999 mm 8.999 m
9. 11m and 772 mm 11.772 m
10. 73m and 156 mm 73.156 m

13

Measure seven things. Record to the nearest thousandth of a meter.

	object	length
1.		
2.		
3.		
4.		
5.		
6.		
7.		

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section 5 decimals: addition and subtraction

Objectives: Given a pair of one-, two-, or three-place decimals, find their sum.

Given a pair of one-, two-, or three-place decimals, find their difference.

Materials: tape measure marked in meters and mm, adding machine tape

Vocabulary: decimal, decimal point, tenths of a meter, hundredths of a meter, thousandths of a meter

SUGGESTED PROCEDURE AND ACTIVITIES:

Addition and subtraction of decimals is included as an application of metrics and to reinforce the students' skills in computation.

1. Cut two pieces of adding machine tape. Have a volunteer measure the length of one piece. Express this length as a three-place decimal on the chalkboard. Then measure the second piece and write the length on the chalkboard. Then ask, "If I taped these together, how long would they be?" Tape them together. Be careful to match the edges so that there is no gap or overlap. Then measure the length of the strip. Verify the length by adding the two lengths on the chalkboard. That sum should match the length of the strip of adding machine tape.

   Explain the procedure for adding decimals: Line up the decimals and proceed as in regular addition, bringing the decimal point straight down in the sum.

2. To illustrate subtraction, cut a piece of adding machine tape, measure its length to the nearest thousandth of a meter, and write the length on the board. Then cut off a piece, measure its length, and record that length on the board. For example,

   1.247 m
   -0.136m

   "Who can tell me how long this remaining piece is?" Perform the subtraction on the board, then measure the strip to verify the results. Point out that subtraction of decimals is just like regular subtraction, with the decimal point moved straight down in the answer.

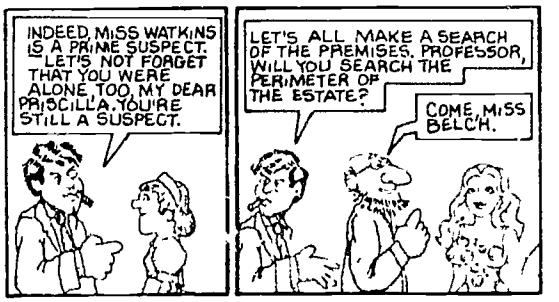
3. Assign pages 15 and 16.

4. You might make up extra problem sheets for additional practice.

Add.

7.412m + 1.361m = 8.773m	5.475m + 2.123m = 7.598m	2.123m + 3.475m = 5.598m
4.003m + 3.040m = 7.043m	9.147m + 0.012m = 9.159m	6.901m + 1.014m = 7.915m
14.125m + 10.125m = 24.250m	2.987m + 0.111m = 3.098m	0.001m + 0.002m = 0.003m
25.189m + 0.001m = 25.190m	2.176m + 1.072m = 3.248m	3.801m + 1.009m = 4.810m

15



1.999m − 0.145m = 1.854m	2.888m − 0.745m = 2.143m	7.777m − 4.362m = 3.415m
6.666m − 1.432m = 5.234m	5.555m − 1.432m = 4.123m	4.444m − 4.123m = 0.321m
9.876m − 1.234m = 8.642m	7.797m − 4.536m = 3.261m	8.808m − 1.701m = 7.107m
8.991m − 1.119m = 7.872m	52.475m − 14.126m = 38.349m	94.175m − 93.175m = 1.000m

16

the 4M company

section 6 · perimeter

Objectives: Given a polygon and the measures of its sides, add to determine the perimeter.

Given a polygon and a centimeter ruler, measure the sides then add to determine the perimeter.

Materials: masking tape, tape measure or meter stick marked in cm

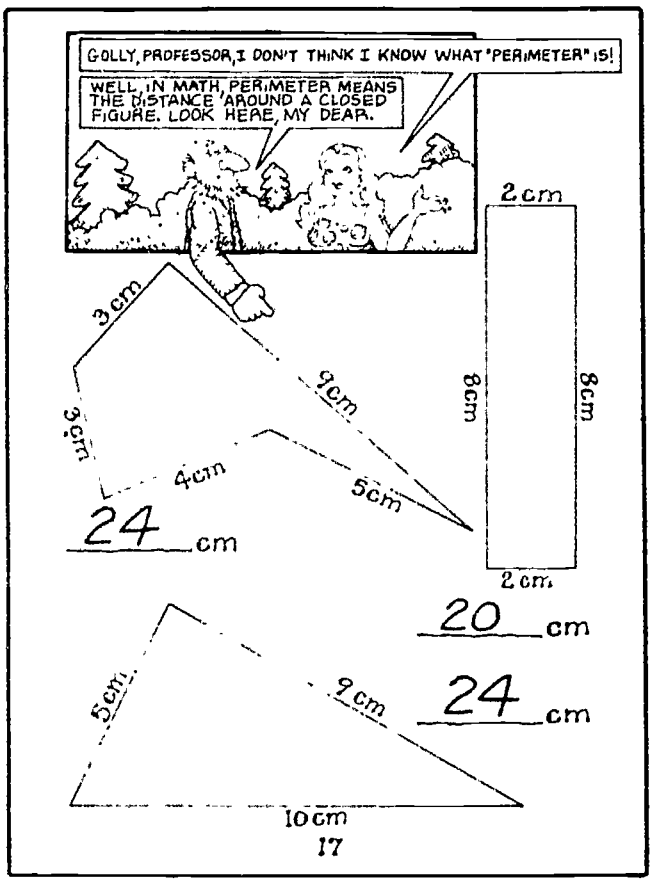
Vocabulary: perimeter, rectangle, triangle, quadrilateral, polygon

SUGGESTED PROCEDURE AND ACTIVITIES:

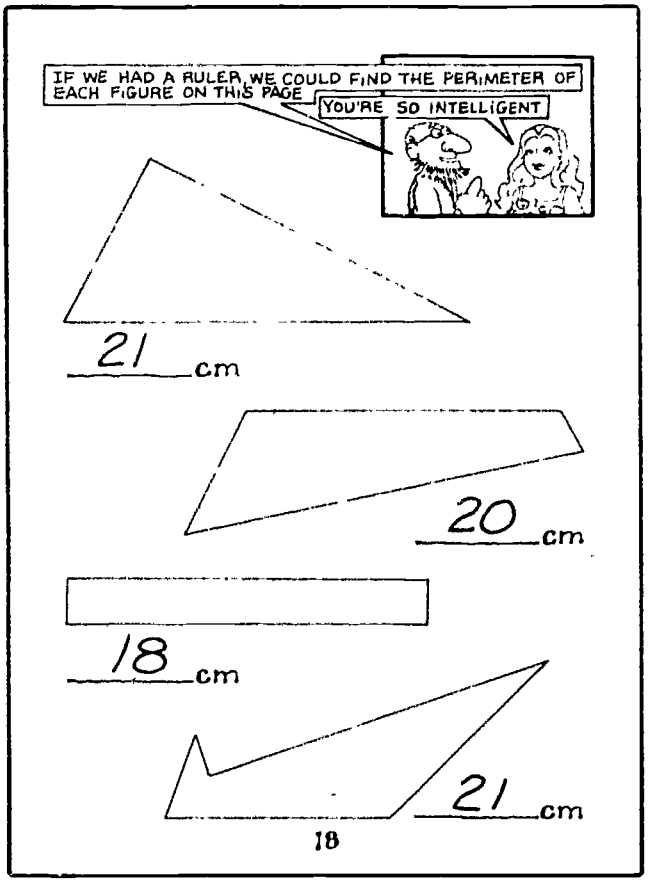
1. Explain that the perimeter of a region is the distance around it. Draw a triangle on the board, measure its three sides, then add to determine its perimeter.

2. Using masking tape, lay out five triangles or quadrilaterals on the floor. Have a pair of students measure the sides (in cm) of one of the figures. Record the lengths on the board, then add to find the perimeter. The other four figures are for page 20.

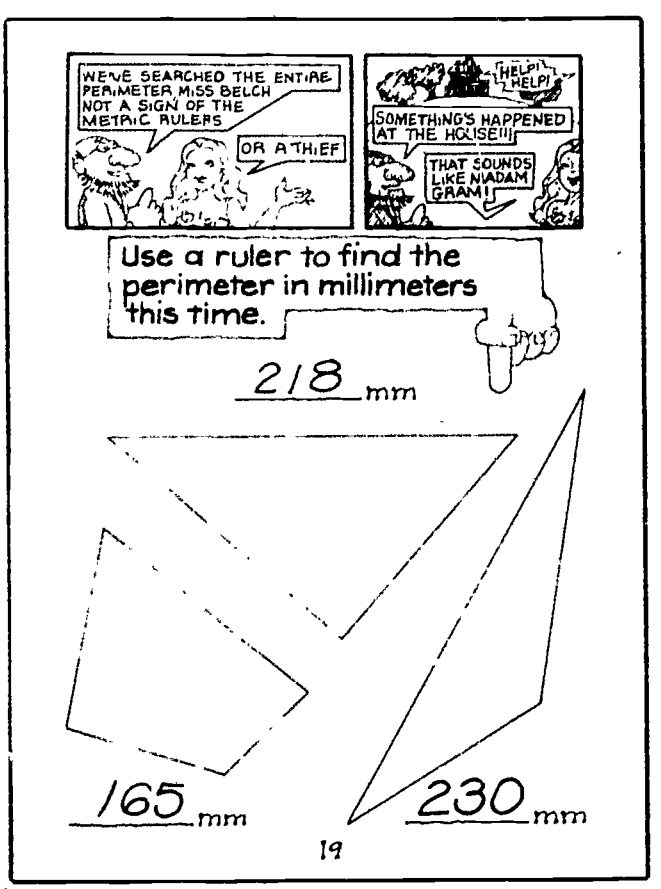
3. Then assign pages 17-20. Students can work in pairs to measure the other four figures on the floor. The perimeters of the floor figures are to be recorded on page 20.


GOLLY, PROFESSOR, I DON'T THINK I KNOW WHAT "PERIMETER" IS!
WELL, IN MATH, PERIMETER MEANS THE DISTANCE AROUND A CLOSED FIGURE. LOOK HERE, MY DEAR.
2cm
8cm
8cm
2cm
3cm
3cm
9cm
4cm
5cm
24 cm
20 cm
5cm
9cm
24 cm
10cm

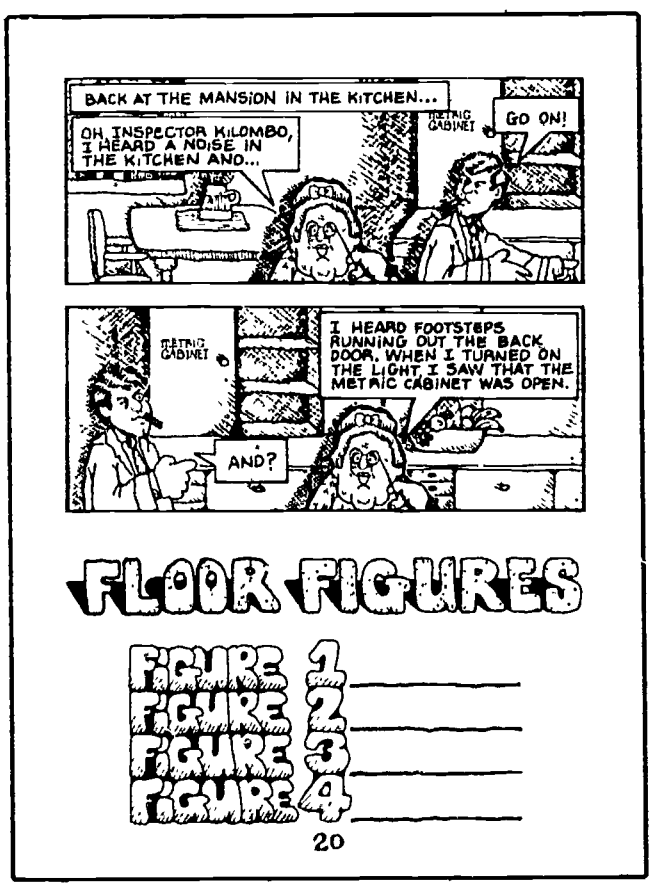
17


IF WE HAD A RULER, WE COULD FIND THE PERIMETER OF EACH FIGURE ON THIS PAGE
YOU'RE SO INTELLIGENT
21 cm
20 cm
18 cm
21 cm

18


WE'VE SEARCHED THE ENTIRE PERIMETER, MISS BELCH NOT A SIGN OF THE METRIC RULERS
OR A THIEF
HELP! HELP!
SOMETHING'S HAPPENED AT THE HOUSE!!!!
THAT SOUNDS LIKE NADAM GRAM!
Use a ruler to find the perimeter in millimeters this time.
218 mm
165 mm
230 mm

19


BACK AT THE MANSION IN THE KITCHEN...
OH, INSPECTOR KILOMBO, I HEARD A NOISE IN THE KITCHEN AND...
METRIC CABINET
GO ON!
METRIC CABINET
I HEARD FOOTSTEPS RUNNING OUT THE BACK DOOR. WHEN I TURNED ON THE LIGHT I SAW THAT THE METRIC CABINET WAS OPEN.
AND?
FLOOR FIGURES
FIGURE 1
FIGURE 2
FIGURE 3
FIGURE 4

20

the 4m company

section 7 · area

Objectives: Given a rectangle and the measures of its sides, multiply to determine the area.

Given a rectangle and a ruler, measure the sides then multiply to determine the area.

Materials: masking tape, several dm^2 and cm^2, cm rulers

Vocabulary: area, square meter, m^2, square decimeter, dm^2, square centimeter, cm^2, square millimeter, mm^2, square kilometer, km^2

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Explain that the area of a region is the amount of surface it contains. Compare different surfaces, such as a wall, a door, the floor, the cover of a book, a table or desk top, etc.

   Then introduce units of area. Form a square meter on the floor using masking tape. Introduce the symbol m^2. Explain that the "2" tells us we have to measure two directions to determine area. Compare the m^2 to the dm^2, cm^2, and mm^2 on page 21. Ask the class, "How many square decimeters will it take to cover this square meter completely?" Bring out the fact that there are 100 dm^2 in a m^2. Similarily, there are 100 cm^2 in a dm^2 and 100 mm^2 in a cm^2. That is, each unit of area is 100 times larger than the next smaller unit.

2. On page 22 explain that area tells us how many squares of a given size it will take to cover a region. Have students count the square centimeters to find the areas on page 22.

3. On page 23 have students connect the dots on the rectangles to form squares. Then count the cm^2 to find the area. Point out that area can be determined by multiplying the lengths of the sides.

4. Pages 24 and 25 contain problems to solve. The last figure on page 25 can be seen as two smaller rectangles.

5. Pose this question to the class and see if they can solve it. "About how many square meters would it take to cover the floor?" Hopefully someone will suggest measuring the length and width of the room and multiplying.

6. Explain that large areas of land are measured in square kilometers (km^2). See if anyone can figure out how many m^2 are in a km^2.

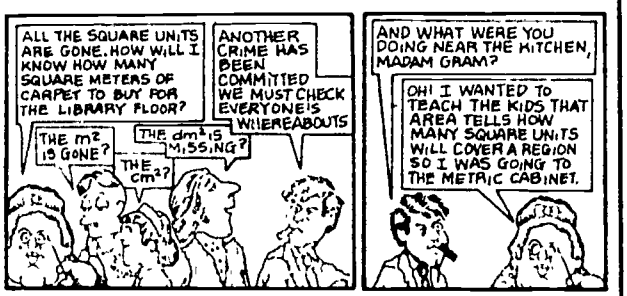
Area is the amount of surface.
Squares are used for area.

Square decimeter (dm^2)

Square centimeter (cm^2)

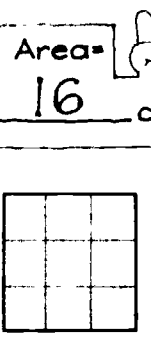
Square millimeter (mm^2)

21

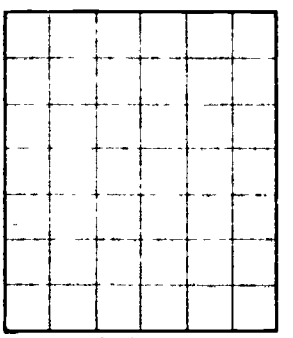


1	2	3	4	5	6	7	8
16	15	14	13	12	11	10	9

Area= 16 cm^2

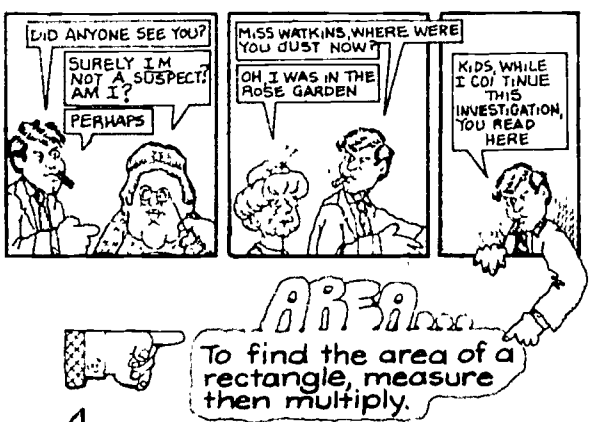


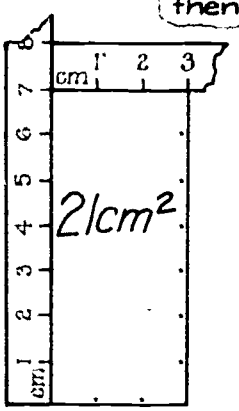
9 cm^2



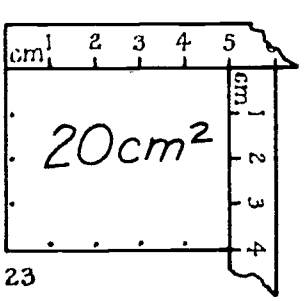
42 cm^2

22

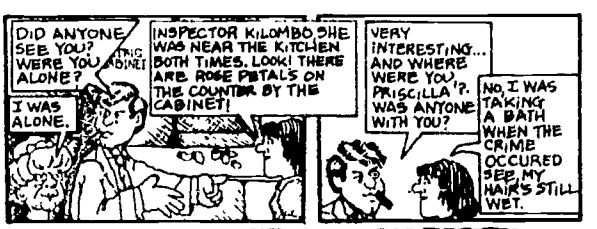




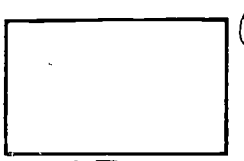
How many cm^2?



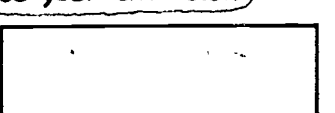
23



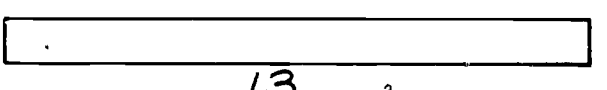
Use your cm ruler.



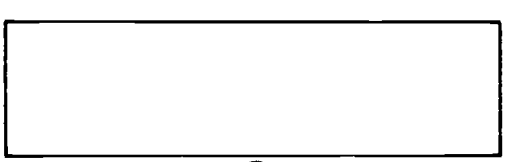
15 cm^2



14 cm^2

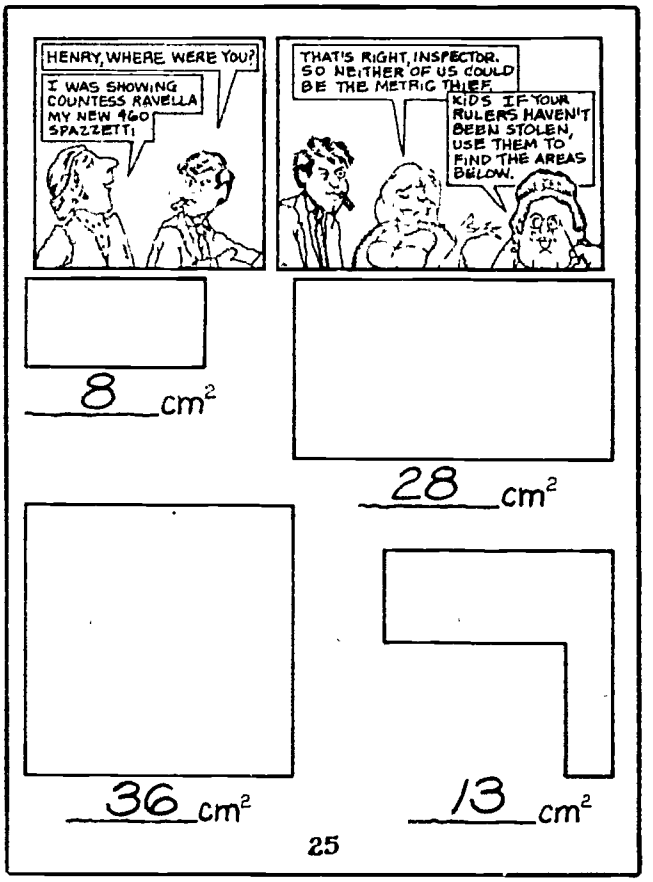


13 cm^2



33 cm^2

24


HENRY, WHERE WERE YOU?
I WAS SHOWING COUNTESS RAVELLA MY NEW 4GO SPAZZETTI
THAT'S RIGHT, INSPECTOR. SO NEITHER OF US COULD BE THE METRIC THIEF.
KIDS IF YOUR RULERS HAVEN'T BEEN STOLEN, USE THEM TO FIND THE AREAS BELOW.
8 cm²
28 cm²
36 cm²
13 cm²
25

the 4M company

section 8 · decimals: multiplication

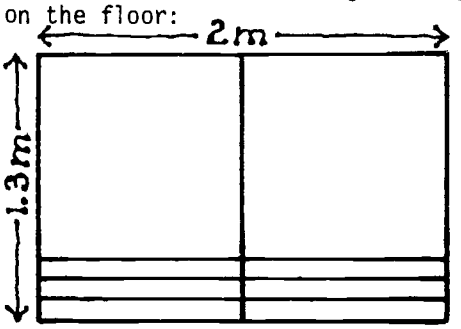
Objective: Given a one-, two-, or three-place decimal, multiply it by a one-digit whole number.

Materials: masking tape

Vocabulary: decimal, decimal point, tenths of a square meter, hundredths of a square meter, product, factors

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Before class use a meter and masking tape to tape the following rectangle on the floor:



It should be 2 m by 1.3 m (in actual size). Use page 26 to discuss the area of the rectangle. Point out that since 10 long rectangles make a whole square meter, each long rectangle is 0.1 m^2. In this case, there are two whole square meters and six long pieces. Hence, the area must be 2.6 m^2.

2. Page 27 illustrates multiplication of a decimal by a decimal. Point out that each small square is 0.01 m^2.

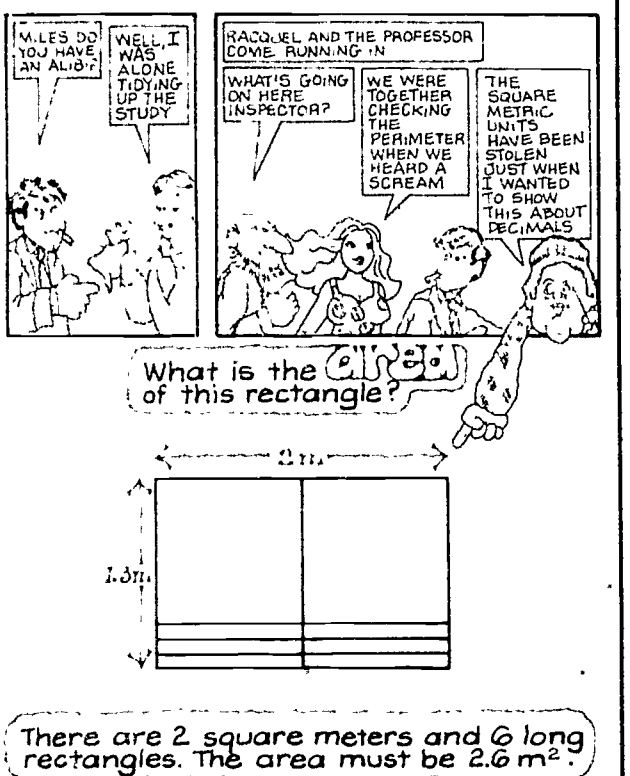
3. Now show how to multiply to get the answers for pages 26 and 27:

$$\begin{array}{r} 1.3 \\ \times\ 2 \\ \hline 2.6\,m^2 \end{array} \qquad \begin{array}{r} 3.1 \\ \times 2.2 \\ \hline 62 \\ 62 \\ \hline 6.82\,m^2 \end{array}$$

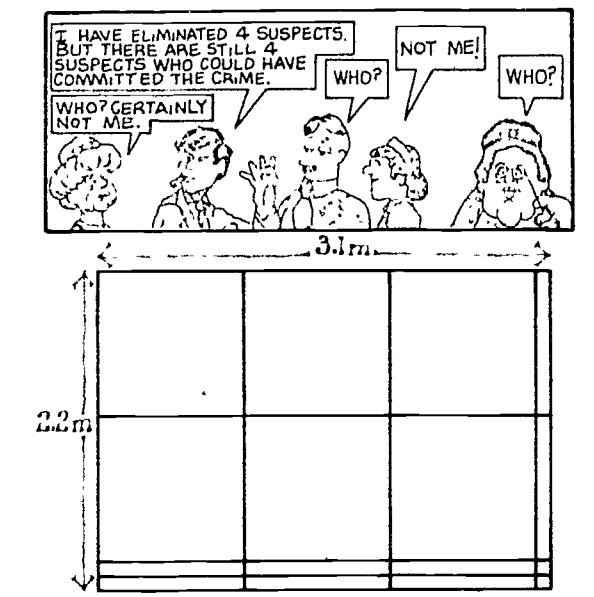
The product must have as many decimal places as the total number of decimal places in the factors.

4. On page 28 students are to place the decimal points correctly. Page 29 provides practice in multiplying. You may want to make up extra problems if more drill is required.

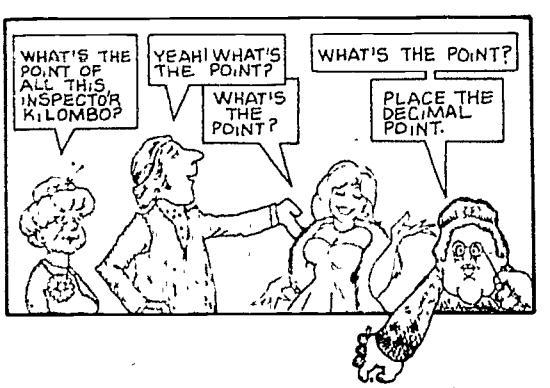
5. On page 30 students are to use an encyclopedia to look up the area of five countries. The area will be given in square miles. To convert to square kilometers, multiply by 2.6. A calculator could be used if one is available.



26



27

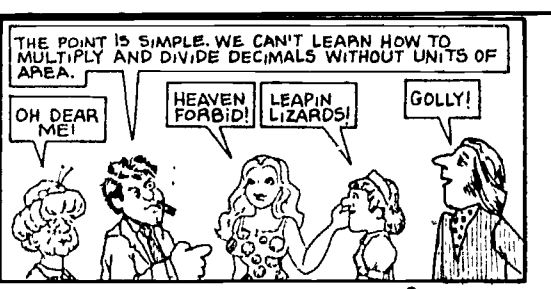


$\begin{array}{r} 2.3 \\ \times\ 4 \\ \hline 9.2 \end{array}$ $\begin{array}{r} 3.3 \\ \times\ 1.2 \\ \hline 66 \\ 33 \\ \hline 3.96 \end{array}$ $\begin{array}{r} 4.63 \\ \times\ 5 \\ \hline 23.15 \end{array}$

$\begin{array}{r} 1.257 \\ \times\ 0.4 \\ \hline .5028 \end{array}$ $\begin{array}{r} 2.07 \\ \times\ 1.4 \\ \hline 828 \\ 207 \\ \hline 2.898 \end{array}$ $\begin{array}{r} 2.795 \\ \times\ 1.36 \\ \hline 16770 \\ 8385 \\ 2795 \\ \hline 3.80020 \end{array}$

$\begin{array}{r} 6.7 \\ \times\ 5 \\ \hline 33.5 \end{array}$ $\begin{array}{r} 1.456 \\ \times\ 0.2 \\ \hline .2912 \end{array}$ $\begin{array}{r} 2.999 \\ \times\ 3 \\ \hline 8.997 \end{array}$

28



$\begin{array}{r} 5.6 \\ \times\ 3 \\ \hline 16.8 \end{array}$ $\begin{array}{r} 2.5 \\ \times\ 4 \\ \hline 10.0 \end{array}$ $\begin{array}{r} 3.7 \\ \times\ 2 \\ \hline 7.4 \end{array}$ $\begin{array}{r} 5.1 \\ \times\ 6 \\ \hline 30.6 \end{array}$

$\begin{array}{r} 2.12 \\ \times\ 6 \\ \hline 12.72 \end{array}$ $\begin{array}{r} 3.45 \\ \times\ 5 \\ \hline 17.25 \end{array}$ $\begin{array}{r} 1.23 \\ \times\ 7 \\ \hline 8.51 \end{array}$ $\begin{array}{r} 4.06 \\ \times\ 6 \\ \hline 24.36 \end{array}$

$\begin{array}{r} 0.132 \\ \times\ 4 \\ \hline 0.528 \end{array}$ $\begin{array}{r} 2.156 \\ \times\ 3 \\ \hline 6.468 \end{array}$ $\begin{array}{r} 5.014 \\ \times\ 9 \\ \hline 45.126 \end{array}$ $\begin{array}{r} 6.132 \\ \times\ 8 \\ \hline 49.056 \end{array}$

29

It's bedtime for them, but for you it's...

ENCYCLOPEDIA TIME

Find the areas of these countries.*

MEXICO	1 976 969.8	km^2
FRANCE	553 113.6	km^2
ENGLAND	130 850.2	km^2
THAILAND	515 429.2	km^2
CHILE	744 629.6	km^2

* Multiply square miles by 2.6 to get square kilometers.

30

Square mileage

Mexico: 760,373 sq. mi.
France: 212,736 sq. mi.
England: 50,327 sq. mi.
Thailand: 198,242 sq. mi.
Chile: 286,396 sq. mi.

the 4m company

section 9 · decimals: division

Objective: Given a one-, two-, or three-place decimal, divide it by a one-digit whole number.

Materials: None

Vocabulary: decimal, decimal point, tenths of a square meter, hundredths of a square meter, divisor, dividend

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Page 31 can serve as a rationale for division of decimals. If the area and the length of one side of a rectangle are known, the other side can be obtained by division.

   Since the area, 28.4 m^2, has one decimal place, the measures of the two sides must have a total of one decimal place; hence the other side is 7.1 m.

2. Use page 32 to provide a rationale for placing the decimal point. Since the area is a two-place decimal, the measures of the two sides must have a total of two decimal places. Hence, the other side is 1.6 m in length. It is perfectly acceptable to teach students to move the decimal points as follows:

   $0.4\overline{)0.64}$

   Move it as far to the right as you can in the divisor. Move it the same amount in the dividend, then go straight up into the answer.

3. On page 33 students are to place the decimal points. Page 34 provides division practice. You may wish to make up more problems if more drill is required.

?

3 m

One side = 3 m
Area = 18 m²
Other side?

DIVIDE! $3\overline{)18}$ → 6

?

4 m

One side = 4 m
Area = 2.84 m²
Other side?

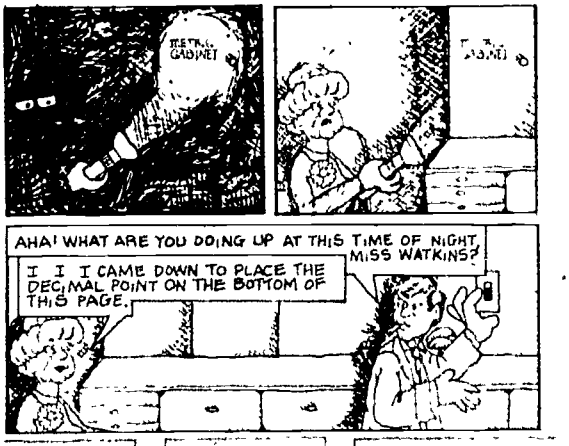
DIVIDE! $4\overline{)28.4}$ → 7.1

28

4

4

31



Rectangle → One side 0.4m → Area = 0.64 m²

Divide → $0.4\overline{)0.64}$ → 1.6

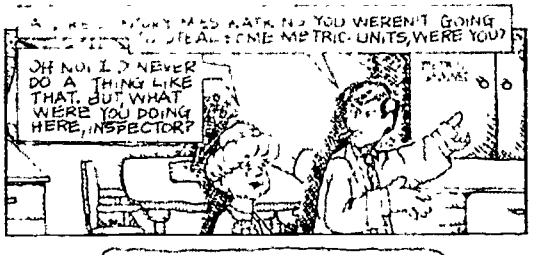
4

24

24

Can you place the decimal point?

32



Place the decimal points for Miss Watkins.

$0.6\overline{)13.38}$ → 22.3

$0.7\overline{)3.185}$ → 4.55

$1.9\overline{)125.59}$ → 66.1

$4.5\overline{)270.45}$ → 60.1

$9\overline{)299.7}$ → 33.3

$1.03\overline{)67.98}$ → 66.

$3.69\overline{)11.8449}$ → 3.21

$0.3\overline{)0.3708}$ → 1.236

$12\overline{)19.80}$ → 1.65

$7.92\overline{)9.6624}$ → 1.22

33

$3\overline{)1.62}$ → 0.54

$4\overline{)5.48}$ → 1.37

$5\overline{)62.5}$ → 12.5

$5\overline{)1.595}$ → 0.319

$5\overline{)4.25}$ → 0.85

$6\overline{)10.26}$ → 1.71

$7\overline{)5.53}$ → 0.79

$8\overline{)8.48}$ → 1.06

$9\overline{)20.07}$ → 2.23

34

the 4m company

section 10 · capacity

Objectives: Given a container and a graduated cylinder calibrated in milliliters, determine the capacity of the container.

Materials: a liter container, graduated cylinder, an assortment of small containers, 10 quarters, water, 10 index cards to make card game (activity #6)

Vocabulary: capacity, liter, L, milliliter, mL, graduated cylinder, thousandths of a liter

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Turn to page 2 of the student booklet and review the entire metric chart. Hold up a liter and explain that in daily living only two units of capacity are commonly used, the liter and the milliliter. Explain that it takes 1000 milliliters to make 1 liter.

   Demonstrate how to use a graduated cylinder marked in milliliters. Explain the calibrations and scale.

2. Assign pages 35 and 36. For page 36, mark 5 small containers (A, B, C, D, E) and set them up at a water station with graduated cylinders.

   Before doing page 36, have students arrange the five containers in order from largest to smallest by guessing. After determining the capacity of each, see how accurate the guesses were.

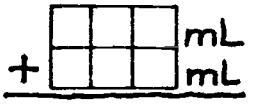
3. Have students bring food labels from home which have contents listed in milliliters. These can be used to make a bulletin board.

4. Find an irregular-shaped object (a rock is fine) and ask the class to estimate its volume. Fill the graduated cylinder about half full and record the water level. Put the rock in the cylinder, and record the new water level. The difference between the new level and the original level is the approximate volume of the rock.

5. As a class activity, find the volume of a quarter. Fill the cylinder about half full and record the water level.

Then place 10 quarters in the cylinder and record the new water level. Divide the rise in water level by 10 to get an approximate volume for one quarter.

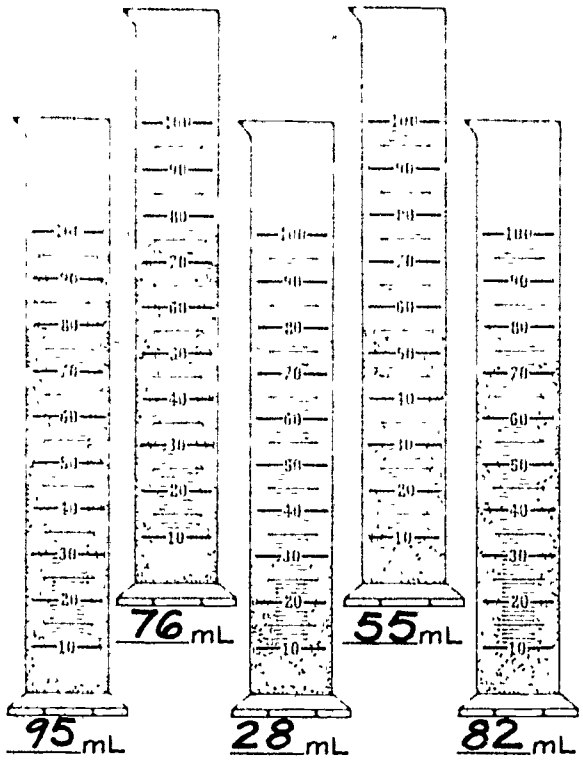
6. Card game: The deck contains 10 index cards with the numbers 0 to 9 on them (one number to a card). Each student makes the following grid on a sheet of paper:



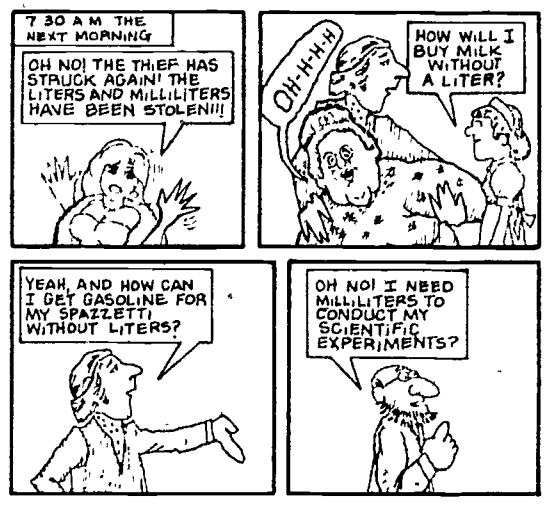
The cards are shuffled and placed face down. One card is turned over and each player decides where he or she wants to write that number in his or her grid. (They are trying to make two numbers whose sum will equal one liter, that is 1000 milliliters.) In all, six cards are turned up. The numbers are added, and the winner is the student whose sum is the closest to 1000 mL.

Alternatives: shoot for some other sum, such as 500 ml. Or subtract quantities with the winner being the closest to zero.

7. On page 37 students are to express milliliters as liters. Explain that each 1000 mL make one liter and a milliliter is 0.001 of a liter.

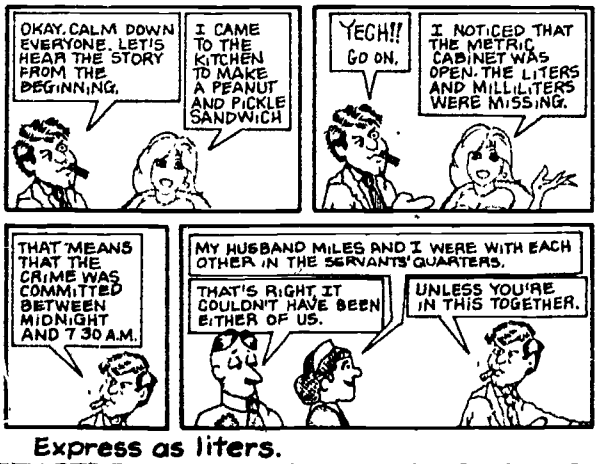


35



Container A holds _____ mL
Container B holds _____ mL
Container C holds _____ mL
Container D holds _____ mL
Container E holds _____ mL

36



Express as liters.

475mL = 0.476 L	752mL = 0.752 L
4863mL = 4.863 L	8476mL = 8.476 L
75mL = 0.075 L	53mL = 0.053 L
6mL = 0.006 L	9mL = 0.009 L
999mL = 0.999 L	13mL = 0.013 L
9007mL = 9.007 L	75016mL = 75.016 L
147mL = 0.147 L	187mL = 0.187 L

37

the 4M company

section 11: three-dimensional drawing

Objectives: None (See statement of purpose below.)

Materials: unit cubes, boxes

Vocabulary: 3-D, three-dimensional, length, width, depth, cubes, space figure

SUGGESTED PROCEDURE AND ACTIVITIES:

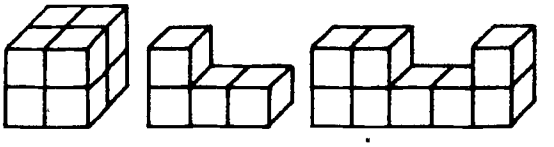
The purpose of this section is to prepare students for Section 12.

1. Use page 38 to help you explain three-dimensional drawings. Space is three-dimensional, but a page has only two dimensions, length and width. To draw pictures of three-dimensional objects, such as boxes, care must be taken to show the proper perspective. Explain that one arrow is pointing away from (or into) the page to show depth.

2. On pages 39 and 40 students are to complete the drawings to make 3-D drawings.

3. Have students practice drawing 3-D shapes on scratch paper. Set up some boxes and have students try to draw them.

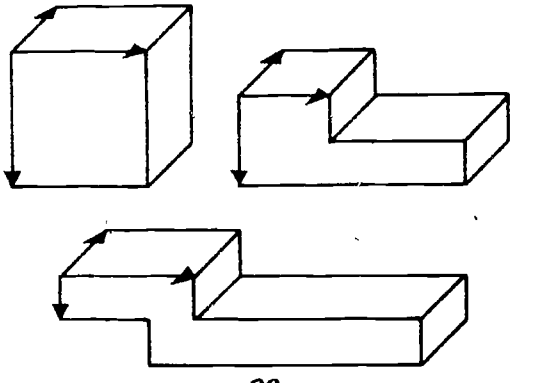
4. Page 41 illustrates how stacks of cubes are drawn. The purpose of this page is to help the students visualize such 3-D drawings properly. You might have them practice drawing some of their own. If unit cubes are available, let students make shapes and try to draw them. For example,



5. Students are to use unit cubes to try to make the shapes on page 42.

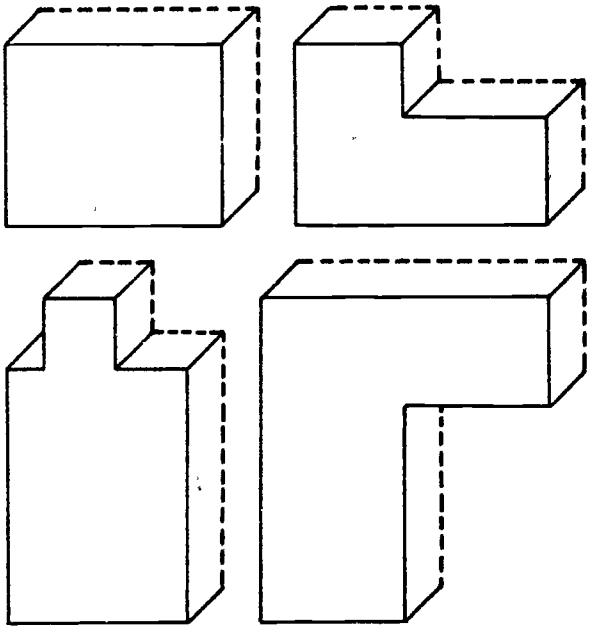
KIDS, WHILE KILOMBO INTERROGATES MY GUESTS LET'S GO TO THE LIBRARY AND STUDY SPACE FIGURES.

SPACE FIGURES are three-dimensional. From a given point we go in three directions.



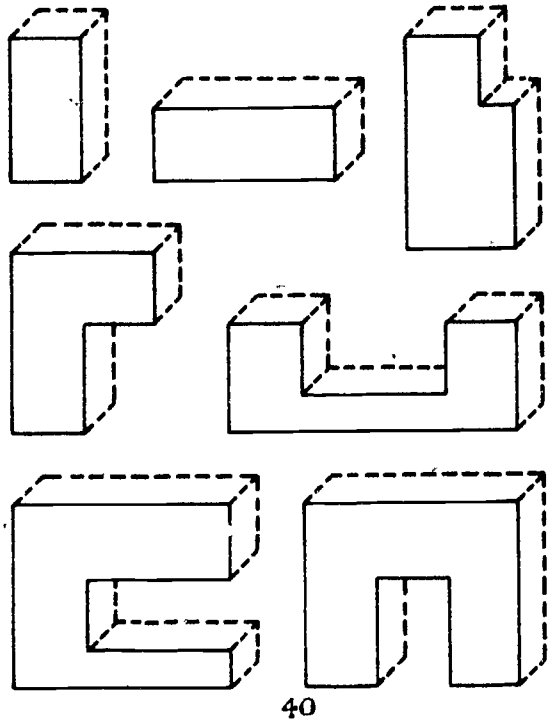
38

Can you make 3-D figures? Part of it is done for you.



39

Can you make **3-D** drawings?



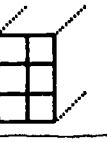
40

DRAWING CUBES

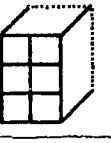
Step 1... Draw a rectangle.

Step 2... Divide it into six squares.

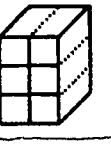
Step 3... Draw parallel lines from verticals.



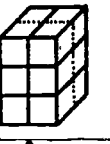
Step 4... Connect endpoints.



Step 5... Draw lines to show depth.



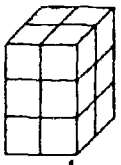
Step 6... Draw lines to show layers.



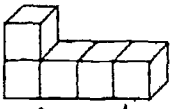
There are 12 cubes in all.

41

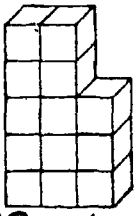
CAN YOU MAKE THESE WITH BLOCKS? HOW MANY CUBES IN EACH FIGURE?



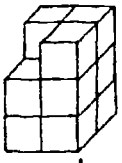
(12 cubes)



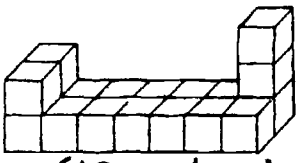
(5 cubes)



(13 cubes)



(11 cubes)



(18 cubes)

42

the 4m company

section 12 · volume

Objectives: Given a rectangular solid constructed of unit cubes, determine the volume.

Given an illustration of a rectangular solid on which cubic units are drawn, count the number of rows, columns, and layers, then multiply to determine the volume.

Materials: unit cubes, cubic centimeters, (plastic) cubic decimeter, 12 meter sticks to make a cubic meter (optional), liter measure, water

Vocabulary: volume, three dimensions, unit cubes, cubic centimeter, cm^3, cubic decimeter, dm^3, cubic meter, m^3

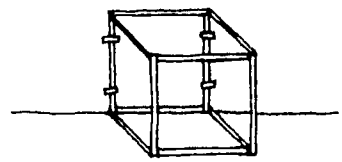
SUGGESTED PROCEDURE AND ACTIVITIES:

1. Construct a 3x2x3 rectangular solid with unit cubes. "How many cubes are in this solid figure? Can you find an easy way to determine the volume?" The volume of rectangular solids can be determined by multiplying its 3 dimensions. In this case, 3 x 2 x 3 = 18, so the volume is 18 cubes.

2. Assign pages 43 and 44.

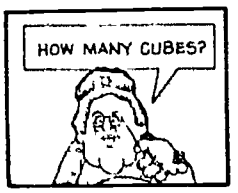
3. On page 45 students will have to be resourceful.

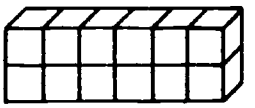
4. Introduce the cubic centimeter as a unit of volume. Write its symbol on the board, "cm^3", explaining that the exponent ^{3} reminds us that the cube is 3-dimensional. Then display a cubic decimeter (dm^3), and finally a cubic meter m^3. If available, 12 meter sticks can be taped together to form a cubic meter. (Tape it in a corner or against a wall for support.)



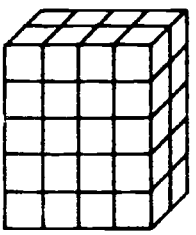
Explain that the cm^3 is for measuring small volumes, the m^3 for large volumes, like the space in the room. Point out that the dm^3 is a very special size. Use a liter measure, a plastic dm^3, and water to show that a dm^3 is a liter. Explain that the liter was defined by the inventors of the metric system to be the capacity of a box one dm on a side (i.e. a cubic decimeter).

5. Assign pages 46 and 47.

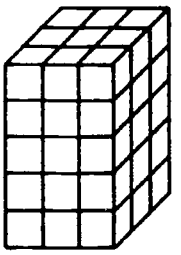




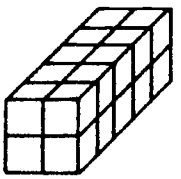
12 cubes



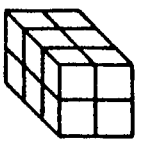
40 cubes



45 cubes

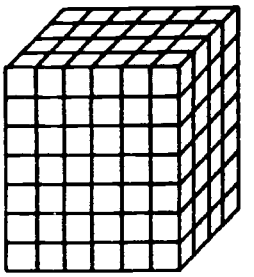


20 cubes

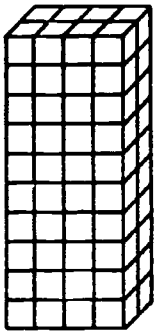


12 cubes

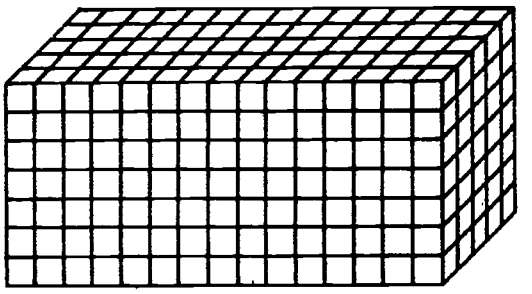
43



168 cubes

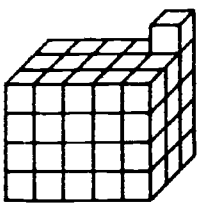


80 cubes

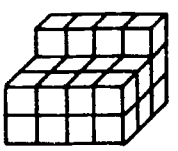


525 cubes

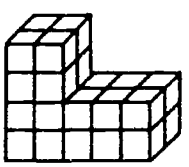
44



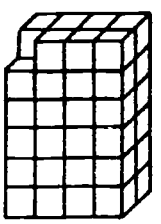
61 cubes



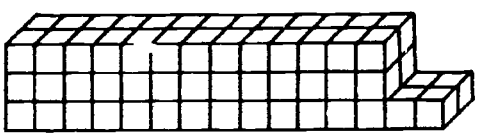
40 cubes



28 cubes

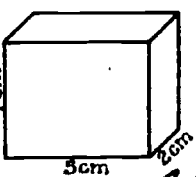


47 cubes

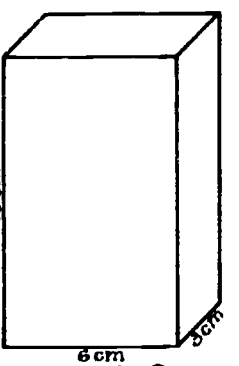


82 cubes

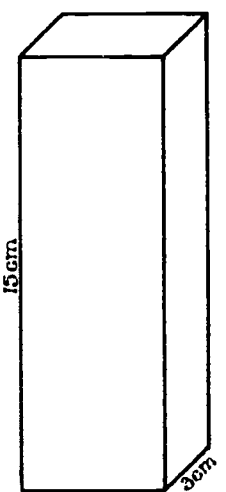
45



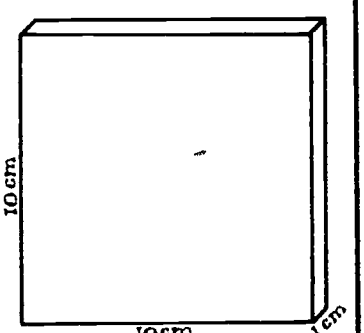
volume = 40 cm³



volume = 180 cm³

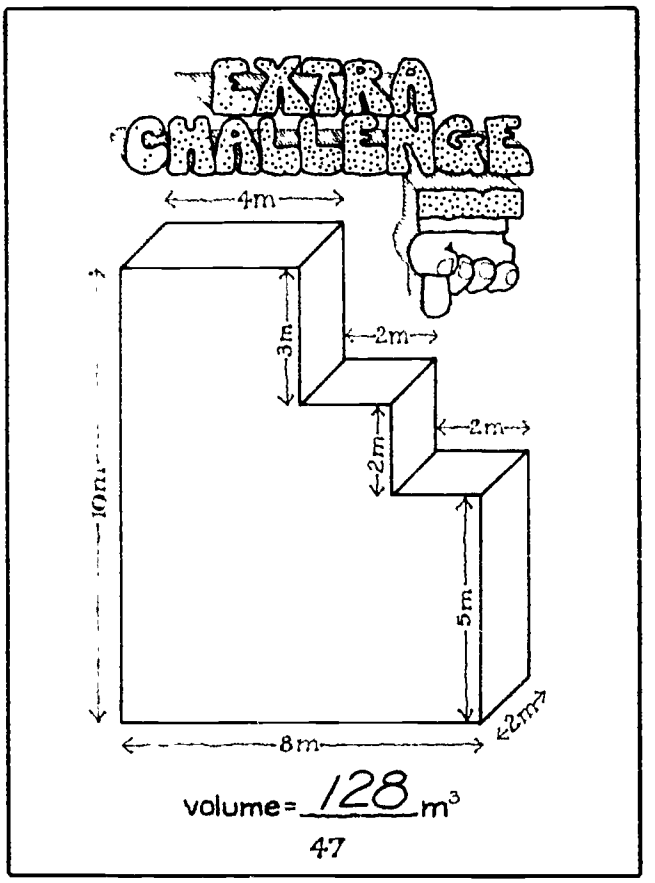


volume 225 cm³



volume = 100 cm³

46


EXTRA CHALLENGE
4m
3m
2m
2m
2m
10m
5m
2m
8m
volume = 128 m³
47

the 4M company

section 13 · mass (weight)

Objectives: Given a small object (mass up to 100 g), a two-pan balance, and a set of metric weights, determine the mass (weight) of the object.

Given a bathroom scale calibrated in kilograms, determine one's own weight to the nearest kilogram.

Explain that a liter of water measures one kilogram.

Materials: 2-pan balance, metric weights, bathroom scale, tape measures, 2 meter sticks, liter container, water, kilogram weight; a pencil, a ballpoint pen, a chalkboard eraser, a glass with some water in it, and a metric booklet; 10 index cards to make card game (activity #6); vitamin bottle or cereal box with mg on it.

Vocabulary: mass, weight, gram, kilogram, hectogram, dekagram, decigram, centigram, milligram, two-pan balance, scale, weights

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Introduce the gram as a main unit of weight in the metric system. As a class demonstration, see how many thumb tacks will balance one gram. If tney keep this number in mind - either 2 or 3 thumb tacks, depending on the brand - they will have an idea of a gram.

2. Have students bring food container labels from home. Most of them will have the contents listed in grams. These can be used for discussion and will make a nice bulletin board display.

3. Set out the balance, the metric weights and the objects pictured on page 48. Working in pairs, students are to weigh the objects and record those measurements on page 48. (Those objects pictured are: a pencil, a ball point pen, a chalkboard eraser, a glass with some water in it, and a metric booklet.)

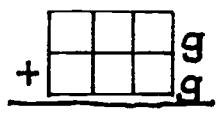
4. While pairs of students are at the weighing station, others can be completing page 49. Explain that a kilogram is 1000 grams, and that we use the kilogram for weighing heavy objects, such as people. Have each student feel the kilogram weight, then weigh themselves on the bathroom scale.

   Tape two meter sticks against a wall for a height measure, and set out some tape measures.

5. As a class demonstration show that a liter of water weighs 1 kilogram, a fact which students should memorize. Place an empty liter container on one

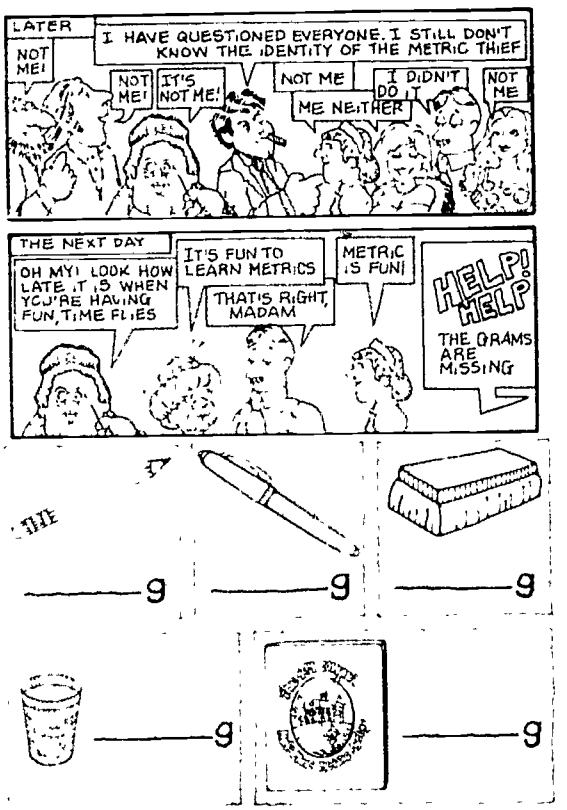
side of a balance, then use gram weights to balance it. Place a kilogram weight on the other side, then fill the liter with water. It should balance (fudge a bit if necessary). Point out the illustration on page 50.

6. Game: Make 10 cards with the numbers 0 to 9, one on each card. Shuffle them, place them face down. Each player makes this grid on his paper:

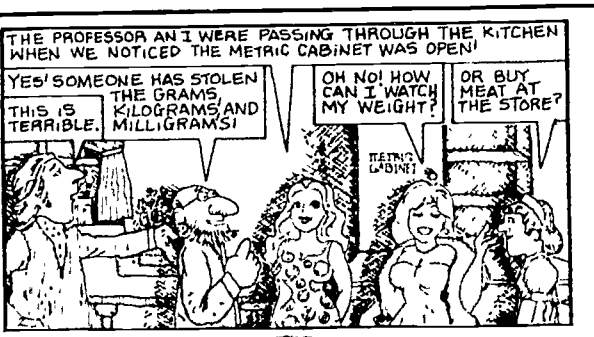


Draw one card. Each student places the number somewhere in his grid. Repeat five more times, then add the numbers. The student closest to 1 kilogram, that is 1000 grams, is the winner.

7. Return to page 2 and discuss the chart. You might want to give a quick spelling review at this time. Then discuss the metric units of weight. The decigram, centigram, and milligram are very small weights. Students can cut out the rectangles on page 51 to get an idea of how light these units really are. You might want to see if 10 decigrams will balance a gram, or if 10 centigrams will balance a decigram. Explain that decigrams and centigrams are not commonly used but milligrams are used a great deal in medicine. Examine a vitamin pill label or cereal box for use of mg.

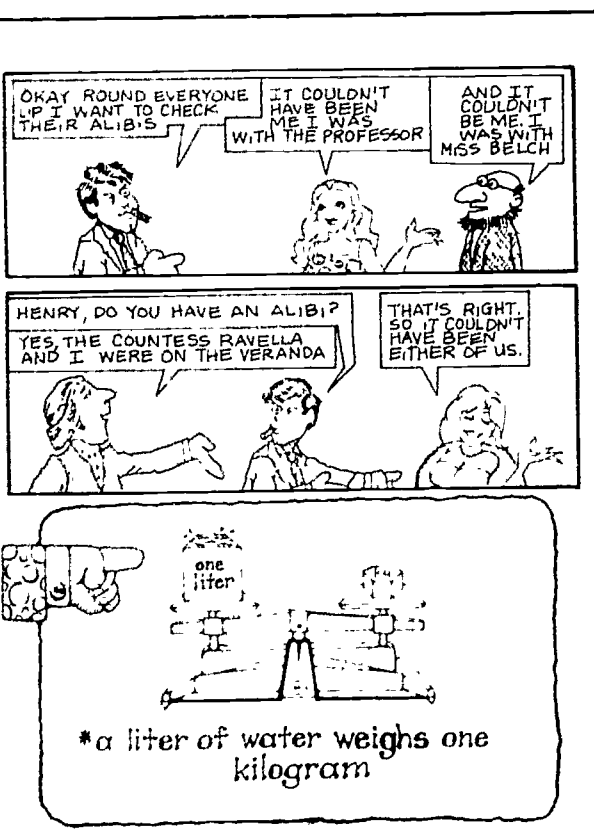


48



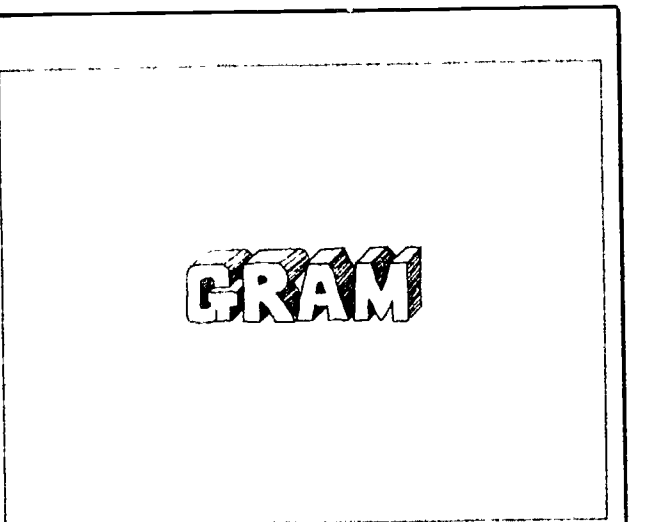
My name is _____.
I am _____ cm tall.
I weigh _____ kg.
My foot is _____ cm long.
My arm muscle is _____ cm around.
My chest is _____ cm around.
My waist is _____ cm around.
My hips are _____ cm around.

49



*a liter of water weighs one kilogram

50



Cut out these small weights.

51

the 4M company

section 14 · temperature

Objectives: Given a Celsius thermometer, read the temperature to the nearest degree.

Given the three temperatures 100°C, 0°C, and 37°C, identify them as the boiling point of water, the freezing point of water, and normal body temperature.

Materials: Celsius thermometers, ice water, boiling water (if available)

Vocabulary: temperature, thermometer, degrees Celsius, °C, boiling point, freezing point, normal body temperature

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Introduce the Celsius scale to the class. As a class demonstration, set out a glass of ice water and a pan of boiling water. Students can file by and read the thermometers.

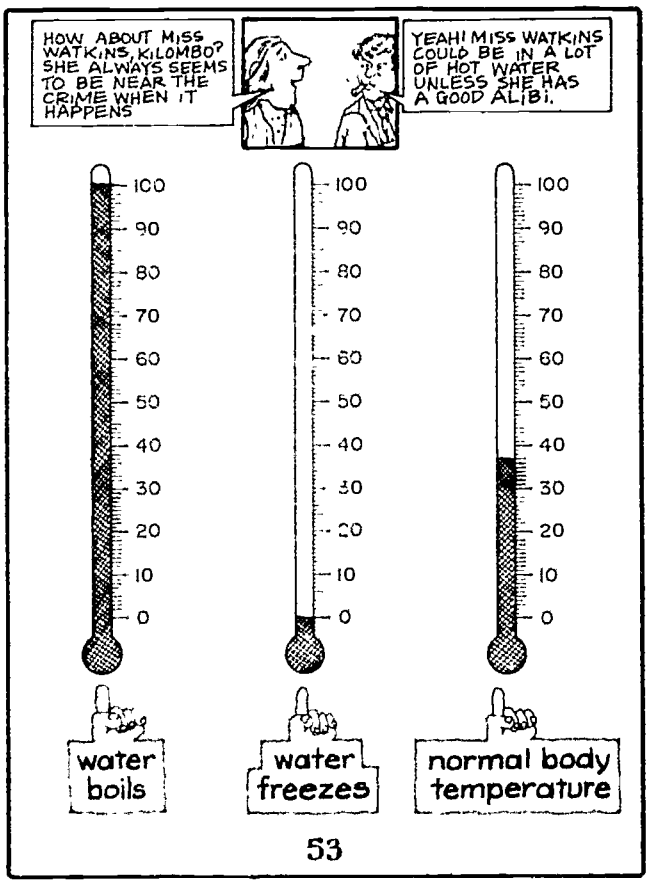
   Students are to shade in the thermometers on page 53 to show 0°C, 100°C, and 37°C. They can hold a thermometer in their hands to see how close to 37°C they can get the thermometer. They should memorize these three temperatures.

2. Have a student hold a thermometer between his palms for a few minutes. Write the temperature on the board. Then have the student rub hands together vigorously and replace the thermometer between the palms. See if the temperature rises.

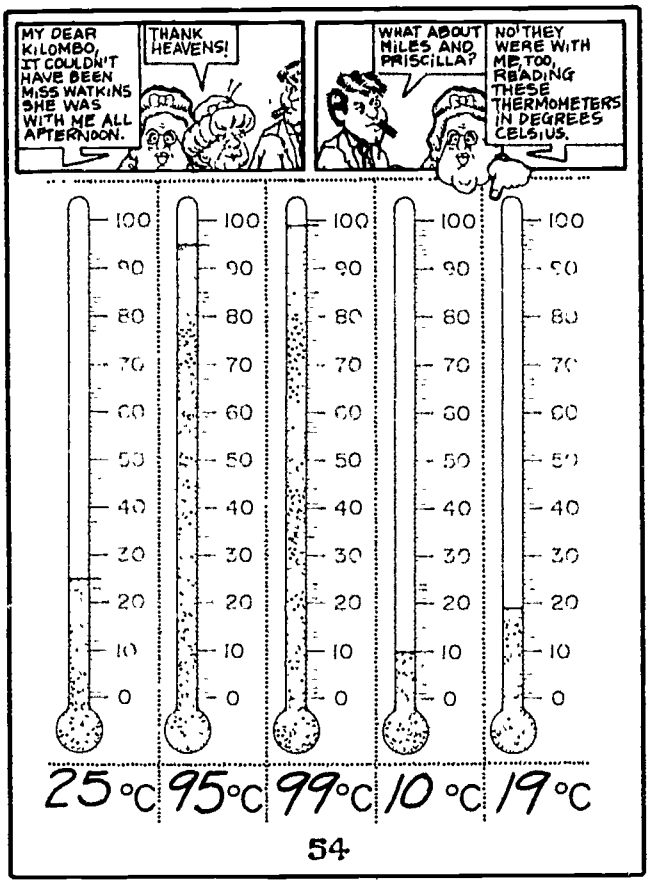
3. On page 54 students are to record the temperatures shown on the thermometers.

4. Provide additional practice reading thermometers. Have students find a hot place, a cold place, etc. Have them write down their estimates of the temperatures in these places, then place thermometers there for 5 or 10 minutes and take the readings.

5. Use temperature readings in degrees Celsius as metric challenges periodically.


HOW ABOUT MISS WATKINS, KILOMBO? SHE ALWAYS SEEMS TO BE NEAR THE CRIME WHEN IT HAPPENS
YEAH! MISS WATKINS COULD BE IN A LOT OF HOT WATER UNLESS SHE HAS A GOOD ALIBI.
100
90
80
70
60
50
40
30
20
10
0
water boils
water freezes
normal body temperature

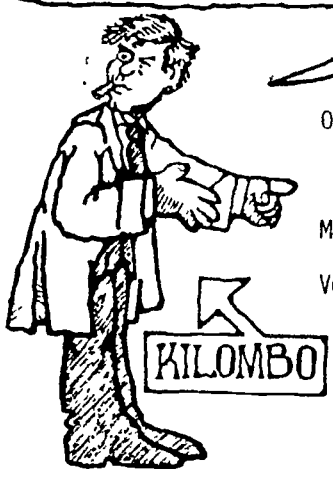
53


MY DEAR KILOMBO, IT COULDN'T HAVE BEEN MISS WATKINS SHE WAS WITH ME ALL AFTERNOON.
THANK HEAVENS!
WHAT ABOUT MILES AND PRISCILLA?
NO! THEY WERE WITH ME, TOO, READING THESE THERMOMETERS IN DEGREES CELSIUS.
25 °C
95 °C
99 °C
10 °C
19 °C

54

the 4m company

section 15 · more metric prefixes



Objectives: Explain that the modern metric system uses more than the six common metric prefixes previously learned.

Materials: None

Vocabulary: mega-, giga-, tera-, peta-, exa-, micro-, nano-, pico-, femto-, atto-

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Page 55 lists all 16 prefixes which now make up the modern metric system. The original metric system, invented in France in the 1790's, had only the six prefixes studied in this book. Scientists have added others through the years, and today there are 16 prefixes. Explain that in everyday usage we will only use the 6 common ones. The others are used primarily in science where there is a need for extremely large units (for space travel and energy for instance) and extremely small units (for microscopic work and computer speeds). Read through the list but do not expect students to remember any but the six common prefixes already studied. Note: a complete chart including symbols and pronunciations appears on page 9 of The Make Mine Metric Mini-Course in the appendix of this Teacher's Guide.

2. Page 56 is merely for fun.

exa means	1 000 000 000 000 000 000
peta means.	.1 000 000 000 000 000
tera means.	1 000 000 000 000
giga means.	.1 000 000 000
mega means	1 000 000
kilo means	1 000
hecto means	100
deka means	10
deci means	0.1
centi means	0.01
milli means	0.001
micro means	.0000 001
nano means.	0 000 000 001
pico means.	.0 000 000 000 001
femto means	0000 000 000 000 001
atto means	.0000 000 000 000 000 001

55

WHO DUNNIT?

These letters were found scattered all around Gram Mansion. Could they be the missing metric units? Unscramble them and see.

teemr	meter
itler	liter
ragm	gram
llltiiirem	milliliter
mmiilleert	millimeter
gllliimarm	milligram
retemolik	kilometer
golarmik	kilogram
teermiecnt	centimeter
dcltreiie	deciliter

56

the 4M company

section 18
conclusion to the Make Mine Metric Mystery

SUGGESTED PROCEDURE AND ACTIVITIES:

1. On page 55 of the student booklet Detective Kilombo asks the students who they think the metric thief is. After a brief discussion with the class about the identity of the thief, read the following conclusion to the MAKE MINE METRIC MYSTERY.

CONCLUSION

Detective Kilombo has Madam Gram and all her guests assembled in the library. He knows the identity of the metric thief and is about to solve the mystery.

"May I have your attention please, friends. By now you may have figured out the identity of the metric thief. There was only one person who didn't have an alibi for each crime -- me."

"You!?" Madam Gram and her guests stared open-mouthed in surprise.

"That's right. I stole your metric units. I even dropped rose petals in the kitchen to divert suspicion to Miss Watkins. Friday night Miss Watkins nearly caught me in the act of stealing the liters. I think she suspected something. Did you suspect me, Miss watkins?"

"Well, I did think it odd that your were in the kitchen at midnight, but I never suspected you were the thief. Mercy me, why did you do it?"

"Because none of you, except Madam Gram, of course, appreciated the metric system. You just took it for granted. I decided to steal the units, one at a time, to make you realize how important the units are. And it worked! Everyone was concerned when the metric units were taken. It made you want to learn about the metric system. And it made you realize how useful our measuring units are. And now, if you'll just follow me, we can find all the missing metric units and use them in the games Madam Gram has planned."

"Oh, Kilombo," called Madam Gram, "you're such a clever fellow!"

"Oh, Mr. Kilombo, you're so intelligent," cooed Raquel Belch. "You're a thousand times smarter than you look."

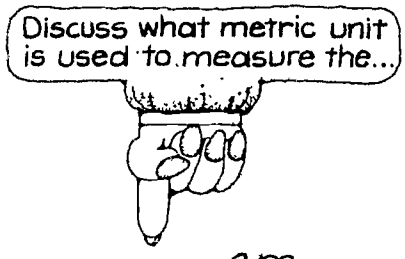
THE END

2. Madam Gram's guests learned how useful the metric units are and how they are used. Use page 57 of the student book to discuss this topic with the class. Do the page with the entire class. Use other examples as necessary. Remind the class that the most commonly used units are: kilometers, meters, centimeters, and milllimeters for length; liters and milliliters for capacity; kilograms, grams, and milligrams for weight; square

kilometers, square meters, and square centimeters for area; and degrees Celsius for temperature.

3. Quickly review addition, subtraction, multiplication, and division of decimals. Refer to student book pages 15, 16, 29, and 34 for examples. Go over the rules for placing the decimal point in each algorithm. Then assign page 58, a secret code. You will have to write the following code on the chalkboard since it is not printed in the student booklet.

A = 4.626
T = 46.26
K = 462.6
H = 0.243
U = 2.43
N = 24.3
O = 0.16
S = 1.6
M = 0.532
D = 5.32
I = 53.2
E = 8.10
R = 81.0
L = 3.21



height of a person cm

weight of a person kg

distance between cities km

amount of vitamins in foods mg

area of a floor m^2

height of a house m

length of an ant mm

width of photographic film mm

amount of gasoline in a car L

length of a person's waist cm

amount of soda pop in a can cL

temperature in a room °C

57

KILOMBO IS A... MYSTERY MESSAGE

41.15 + 5.11	0.140 +0.103	0.06 +0.10	2.22 +0.21	1.2 +0.4	2.300 +2.326	21.6 + 2.7	0.26 +5.06
46.26	0.243	0.16	2.43	1.6	4.626	24.3	5.32
T	H	O	U	S	A	N	D

23.13 x 2	13.3 x 4	0.076 x 7	1.62 x 5	0.8 x 2
46.26	53.2	0.532	8.10	1.6
T	I	M	E	S

0.4 x 4	0.266 x 2	1.542 x 3	40.5 x 2	7.71 x 6	1.35 x 6	9.0 x 9
1.6	0.532	4.626	81.0	46.26	8.10	81.0
S	M	A	R	T	E	R

86.72 -40.46	8.343 -8.100	9.970 -5.344	48.6 -24.3
46.26	0.243	4.626	24.3
T	H	A	N

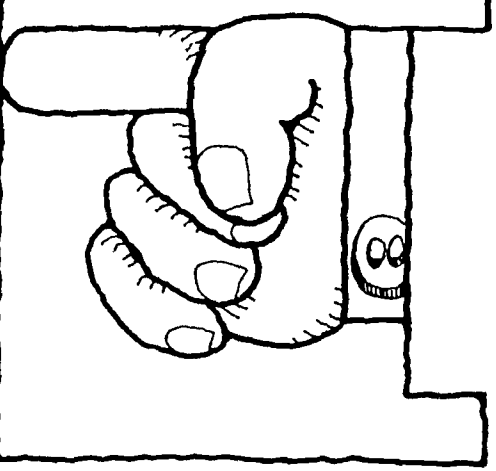
0.573 -0.330	16.52 - 8.42
0.243	8.10
H	E

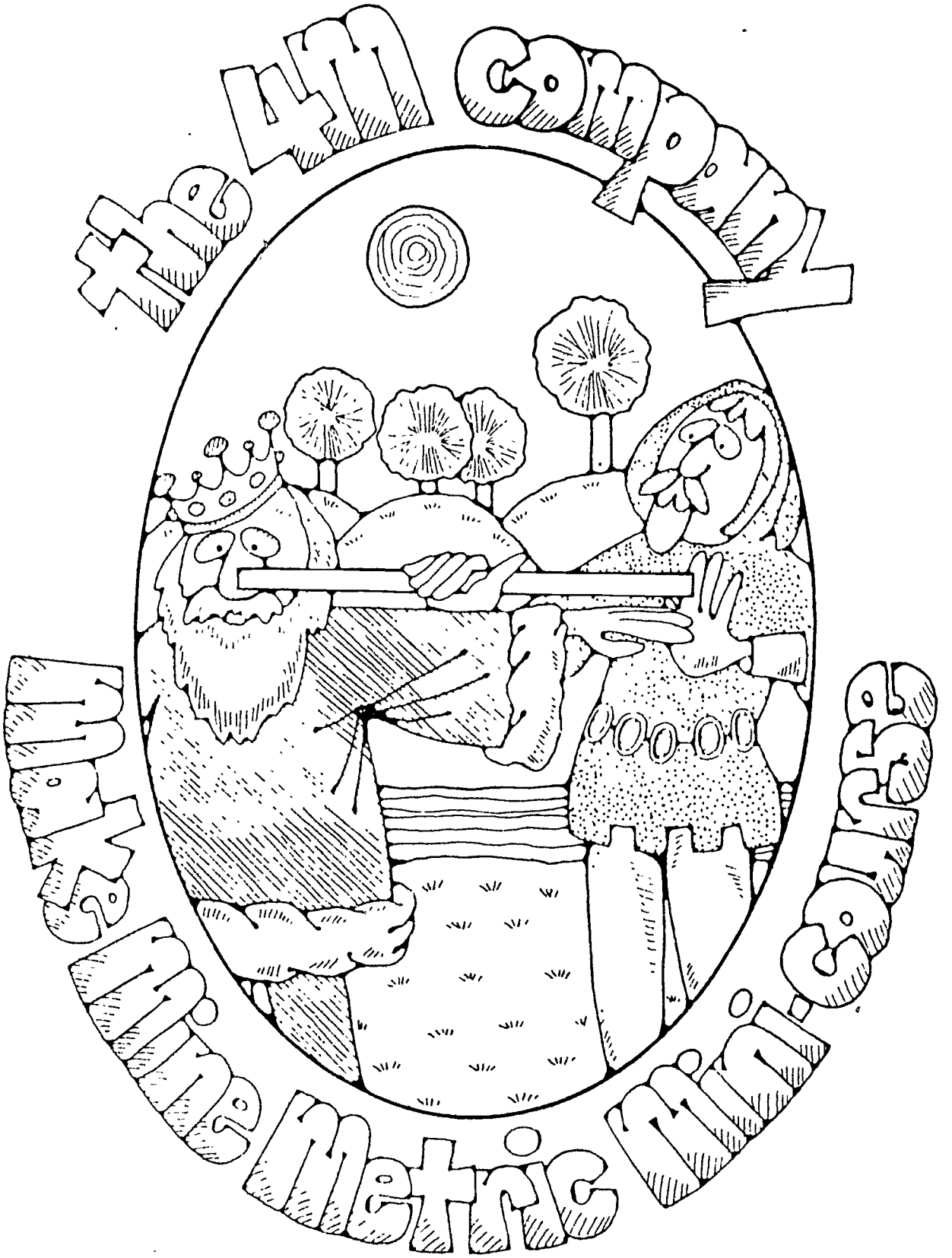
L	O	O	K	S
3.21	0.16	0.16	462.6	1.6
3|9.63	5|0.80	7|1.12	2|925.2	9|14.4

58

Learn the metric system

1000	kilometer (km)	kiloliter (kL)	kilogram (kg)
100	hectometer (hm)	hectoliter (hL)	hectogram (hg)
10	dekameter (dam)	dekaliter (daL)	dekagram (dag)
1	meter (m)	liter (L)	gram (g)
0.1	decimeter (dm)	deciliter (dL)	decigram (dg)
0.01	centimeter (cm)	centiliter (cL)	centigram (cg)
0.001	millimeter (mm)	milliliter (mL)	milligram (mg)





INTRODUCTION

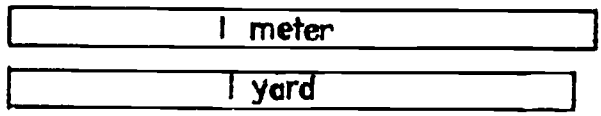
This mini-course is designed to serve two purposes: 1) a quick review of metrics for teachers who have attended a metric workshop; and 2) a basic introduction to the metric system for teachers who have not attended a metric workshop. If studied seriously, we feel the contents of this mini-course can prepare a teacher to teach the metric system. However, don't expect to be an expert right away. Even teachers who have attended a workshop frequently forget much of what they learned. As most teachers know, we usually don't know a subject well until we have taught it a time or two. The same will be true of metrics.

TABLE OF CONTENTS

LESSON 1: THE METER, THE LITER, AND THE GRAM

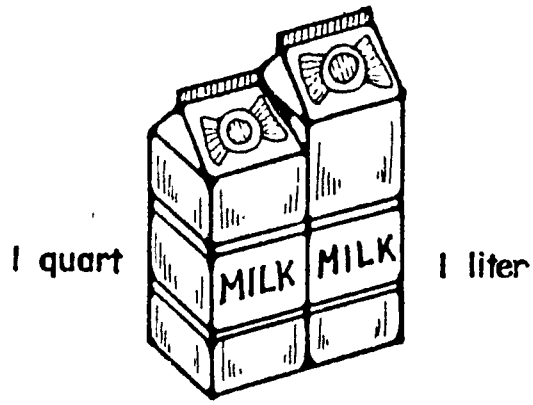
The three most common metric units are the meter (for measuring length or distance), the liter (for measuring liquid or granular capacity), and the gram (for measuring weight). Select a meter, a liter, and a gram from your metric supplies.

The meter is the main unit of length in the metric system. Stand up and hold the meter stick on the floor against your leg. How high up your leg does it come? To your hip? To your waist? Remember the spot and you'll always have some idea of a meter. A meter is just a little longer than a yard -- 39.36 inches.

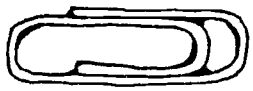


The liter is the main unit of capacity in the metric system. It was originally defined to be the capacity of a cube each of whose sides was 1/10th of a meter long.

Take a good look at the liter. Does it appear to be about the size of any English unit? Actually, the liter is slightly larger than a quart (6% larger, to be exact).



Now pick up the gram, the main unit of weight in the metric system. Pretty light, isn't it? If you look at the protein, fat, and carbohydrate content of the sides of cereal boxes you'll notice that the weights are given in grams. A paper clip weighs about one gram. A nickel weighs 5 grams.


weighs 1 gram


weighs 5 grams

These three units - meter, liter, and gram - are the heart of the metric system necessary for everyday measuring. Try to remember the size of each unit: the meter is a little longer than one yard; a liter is a little larger than a quart; and a gram is the weight of a paper clip.

LESSON 2: OTHER UNITS - PRESTO!

In the English system of measurement there are 14 units of length, and there is no systematic relationship between them:

12 inches = 1 foot

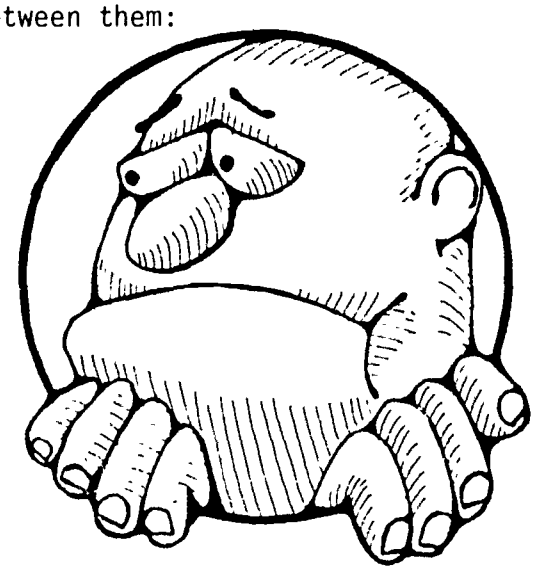
3 feet = 1 yard

5½ yards = 1 rod

40 rods = 1 furlong

8 furlongs = 1 mile

etc.



One would have to be a near-genius to remember all the relationships in the English system!

By comparison, the metric system is simple (although it may not seem so at first). In the metric system there is one base unit for each physical property to be measured. To form units larger or smaller than the base units, a system of prefixes, each of which is a power of ten, is used. For units smaller than the base units, the Latin words for tenth, hundredth, and thousandth are used (deci, centi, and milli). To form units larger than the base units, the Greek words for ten, hundred, and thousand are used (deka, hecto, and kilo). The new units are formed by placing the prefixes in front of the base units.

	LENGTH	CAPACITY	MASS (WEIGHT)
1000	kilometer (km)	kiloliter (kℓ)	kilogram (kg)
100	hectometer (hm)	hectoliter (hℓ)	hectogram (hg)
10	dekameter (dam)	dekaliter (daℓ)	dekagram (dag)
1	meter (m)	liter (ℓ)	gram (g)
0.1	decimeter (dm)	deciliter (dℓ)	decigram (dg)
0.01	centimeter (cm)	centiliter (cℓ)	centigram (cg)
0.001	millimeter (mm)	milliliter (mℓ)	milligram (mg)

Whenever kilo is heard, we know immediately that we have 1000 of the base unit, whatever it is. Thus, kilometer is 1000 meters, kiloliter is 1000 liters, kilowatt is 1000 watts, etc. (The watt is a unit of power.) Or, millimeter is 0.001 meter, milliliter is 0.001 liter, etc.

The writing of metric units is simplified by the use of symbols: m stands for milli, c for centi, d for deci, da for deka (the a is needed to distinguish deci from deka, both of which start with d), h for hecto, and k for kilo. Also, m for meter, ℓ for liter, and g for gram. Thus kg is kilogram, mℓ is milliliter, etc. In the next lesson you will practice using these metric prefixes.

LESSON 3: PRACTICE WITH PREFIXES

In this lesson you will practice using metric prefixes. Use the table in Lesson 2 to help you complete the following equations. Answers appear at the end of the Teacher's Guide.

100 grams =	hectogram	100 liters =	
10 liters =		1000 liters =	
1000 meters =		1000 grams =	
0.001 gram =		10 meters =	
100 liters =		0.1 meter =	
0.01 gram =		0.1 liter =	
0.001 meter =		0.01 liter =	
0.01 meter =		0.1 gram =	
0.001 liter =		10 grams =	

Keep going! Try these!

10 cards = dekacards (get it?)

0.1 Arnaz =

0.01 mentalist =

1000 manjaros =

0.001 tary =

0.1 mate =

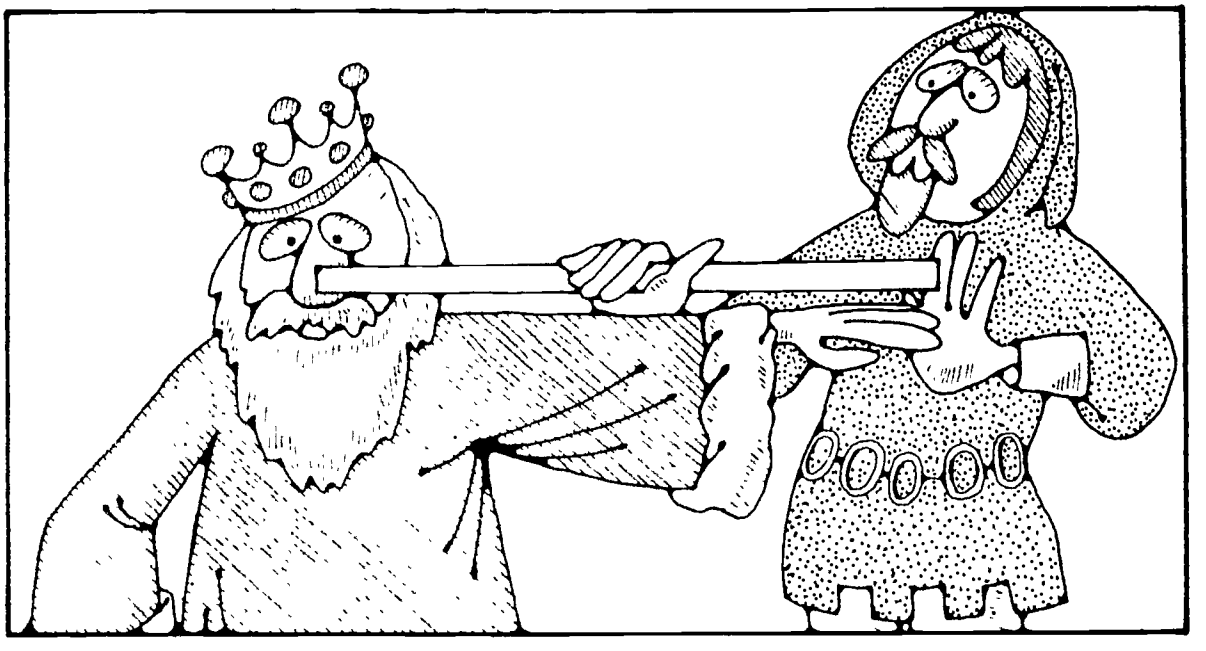
1000 whats? =

0.001 scent =

0.01 pede =

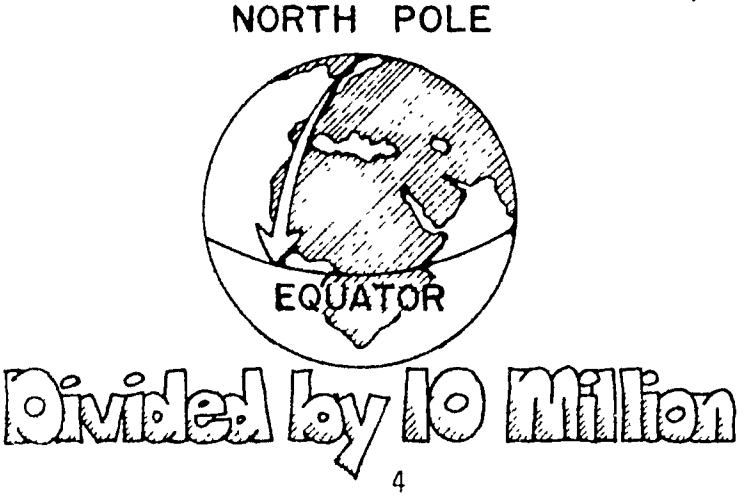
LESSON 4: A BRIEF HISTORY OF THE METRIC SYSTEM

Prior to 1790, the measurement systems of Europe were based on arbitrary objects: an inch was once defined to be the length of 3 kernels of barley corn placed end-to-end; a rod was the combined left feet of the first 16 men coming out of a specific church on Sunday morning; an acre was the amount of land a team of oxen could plow in one day; the yard was the distance from the tip of King Henry I's nose to the tip of his extended middle finger; etc.

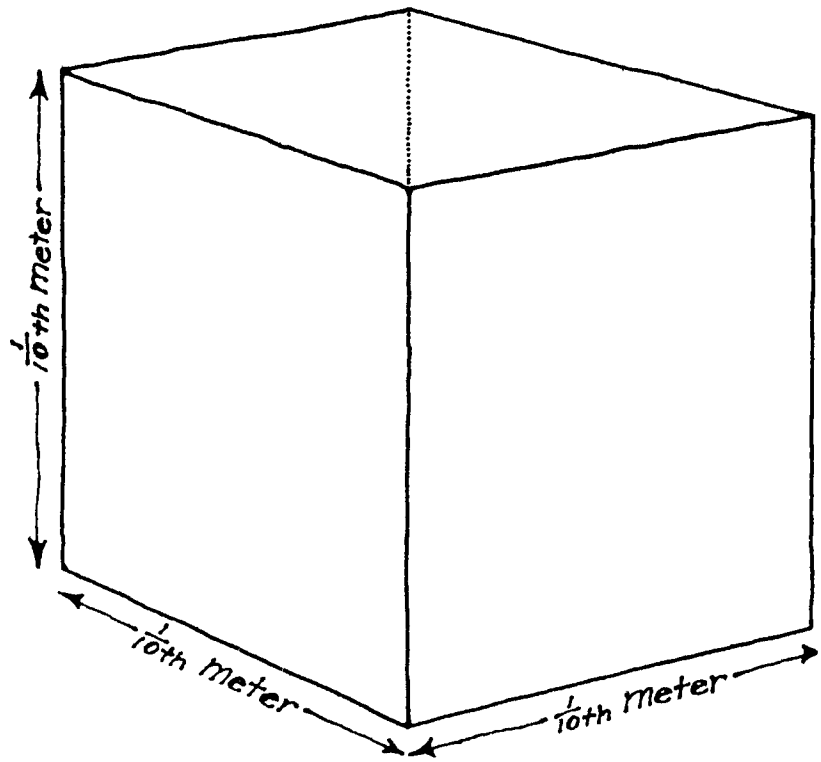


A similar hodge-podge of units was used in France at the time of the French Revolution. In 1789, the French Academy of Sciences was requested by the National Assembly to devise a new measurement system. The French Revolution was underway, and because of the antiaristocratic attitude of the French people, a change to a system not based on dimensions of royal monarchs was highly acceptable to them.

In developing the metric system the French scientists had three major objectives. The first objective was to find a unit of length that was measurable and reproducible everywhere, and natural in the physical world. To meet this objective, the meter was defined to be one ten-millionth of the distance from the equator to the north pole.

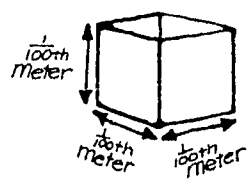


The second objective was to relate the unit of length to other units of measurement. For the main unit of capacity they selected a cube, with each of its sides equal to 1/10th of a meter (cubic decimeter), and called the amount of space contained within this box-shaped figure a "liter."



Liter

For the main unit of mass, the French scientists took a cube with each of its sides equal to 1/100th of a meter (a cubic centimeter), filled this box with pure water at 4° Centigrade, and designated the mass of this water as a "gram." Thus, the meter was used to define both the liter and gram.

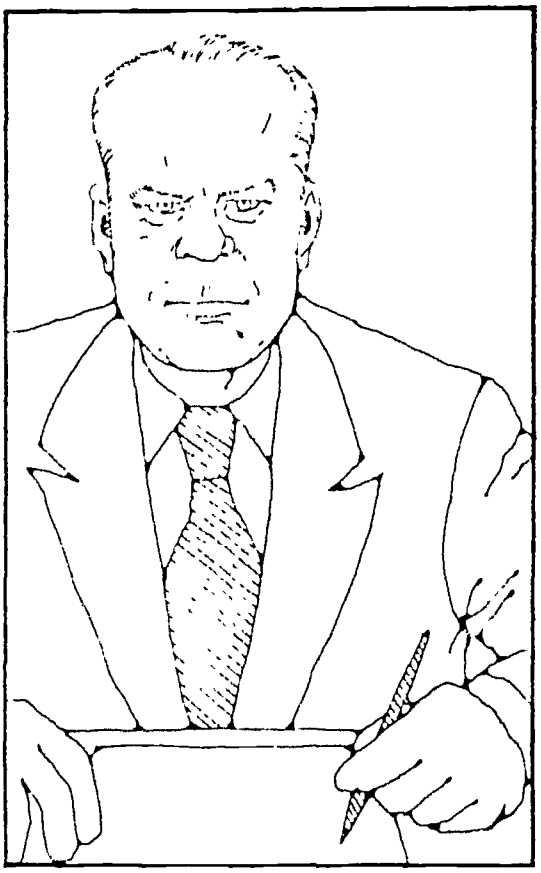


Gram

The third objective was to simplify the conversion from one unit to another. We have already seen how a system of prefixes, which are powers of ten, was used to accomplish this objective. Since each metric unit is ten times larger than the next smaller unit, converting from one unit to another can be accomplished by merely moving a decimal point. Thus

35 meters =
- 0.035 kilometers
- 0.35 hectometers
- 3.5 dekameters
- 350 decimeters
- 3500 centimeters
- 35 000 millimeters

Scientists adopted the metric system immediately, for it made their work much simpler. Nations, on the other hand, have been slow to adopt it. It wasn't until 1840 that the French government made its use mandatory. By 1900, thirty-five nations had officially adopted it, and by the middle of this century, the main holdouts were the English-speaking nations. In 1965, England joined the European Common Market. Since Europe used the metric system, England decided to go metric. The other English-speaking nations soon followed. Ten years later, President Ford signed the Metric Conversion Act of 1975. Finally, after 180 years, the conversion to metric is nearing completion.

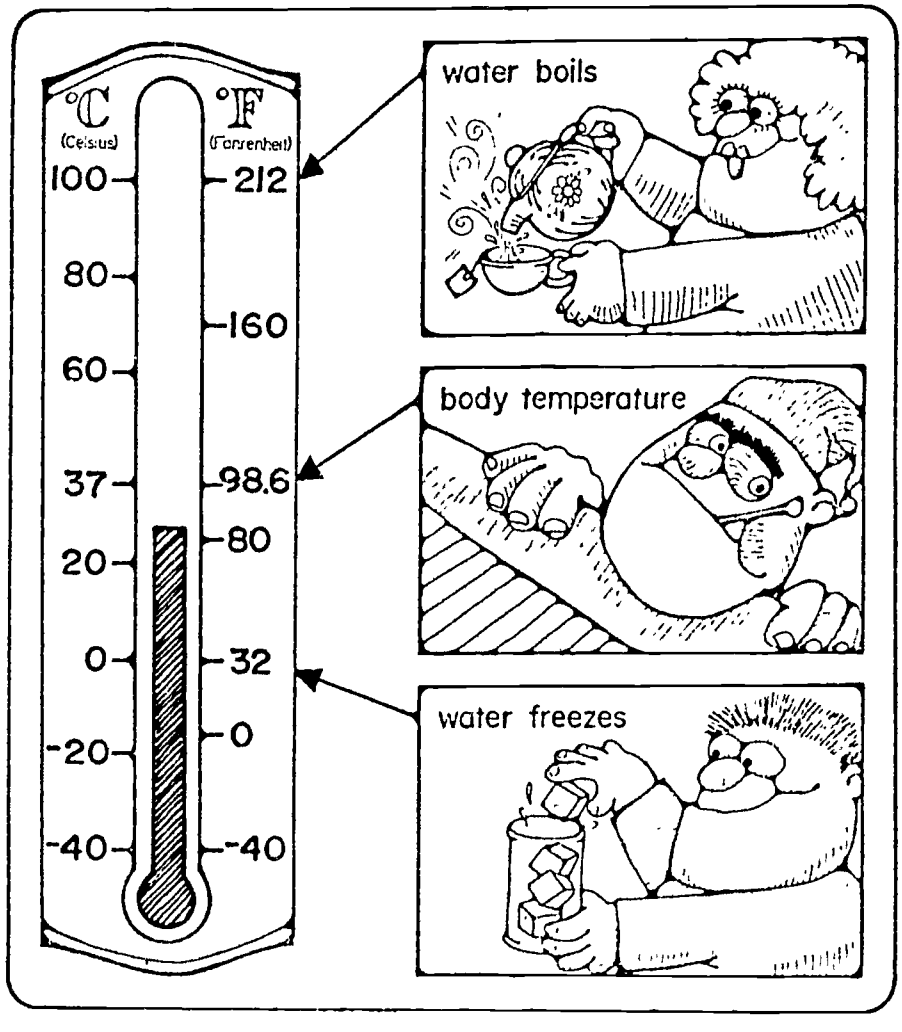


LESSON 5: TEMPERATURE

There is one more metric unit which is encountered in daily living, the unit for temperature, degree Celsius (pronounced sell-see-us). Most adults are surprised to learn that "degree Centigrade," which they vaguely remember from their school days, has been changed to "degree Celsius."

The change came about in 1948, at the General Conference on Weights and Measures which convenes periodically to review and ratify measurement standards. A debate arose concerning the name of a unit for metric temperature. Some conferees favored the English "degree Centigrade," and others favored the French "degré centisimal". By coincidence, the centigrade scale had been invented by Anders Celsius. Since his last name started with "C," his name was selected as a compromise.

The Celsius scale is simpler than the Fahrenheit scale. The drawing below illustrates its simplicity. Water boils at 100°C and freezes at 0°C. If you can remember the four temperatures shown on the thermometer, you'll have a good beginning on making sense of the Celsius scale.



LESSON 6: MASS (WEIGHT?)

The purpose of this lesson is to explain the difference between mass and weight. The kilogram is the unit of mass, and the Newton (after Sir Isaac Newton) is the unit of weight.

If you were an astronaut in outer space, the objects in your space craft would have very little weight. If you held a bowling ball in your hand and released it, it wouldn't fall. It would remain suspended in space. If the bowling ball were placed on a scale, it would read zero. It would be weightless. Why? Because the bowling ball is so far from the earth that it has escaped the pull of the earth's gravity.

Weight, then, is a measure of gravitational pull on an object. The weight of an object can vary, depending on where it is in the universe.

The mass of an object never varies. It is the same on earth as anywhere else in the universe. Mass is a measure of how much matter an object contains. The bowling ball is weightless in space, but it still has the same mass. Because of its mass, if you kicked it with your bare foot it would still hurt, whether you were on earth or in a spaceship.

We determine the weight of an object by spring scales which measure the downward pull on an object placed on it. This downward force is measured in Newtons. The mass of an object, on the other hand, is determined by using a balance: the object is placed on one side and balanced with standardized mass pieces. This is what a pharmacist does when he mixes a compound.

However, the mass of an object is directly proportional to its weight on earth. That is, a one-kilogram mass has a weight of about 9.8 Newtons at sea level; a two-kilogram mass has a weight of about 19.6 Newtons; etc. Thus, either mass or weight gives us a good measure of how much matter an object contains. Therefore, in everyday usage spring scales are used for determining mass in kilograms because it is much more convenient than using a balance. The 4M COMPANY uses the words interchangeably - mass (weight). For everyday usage, the distinction is unimportant.

LESSON 7: SI

The French scientists made several errors in their original calculations. For example, they miscalculated the distance from the equator to the north pole by about 2000 meters, and instead of being equal to one cubic decimeter, the liter was actually equal to 1.000028 cubic decimeters.

To correct these errors, various scientific organizations of the world met in 1960 to devise a modern metric system which is called the International System of Units (or SI for short, after the French Le Systéme Internationale d'Unités). SI was created to meet the exacting demands for precise scientific measurement. Most of the units and prefixes will not be used by the average citizen. But for the sake of completeness, we include a list of the base units and all the prefixes.

BASE UNITS

Quantity	Name	Symbol
length	meter	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
thermodynamic temperature	kelvin	K
amount of substance	mole	mol
luminous intensity	candela	cd

Two units not on the list above are commonly used with the metric system. Instead of referring to liquid capacity in terms of cubic decimeters, the liter is used. And instead of using the Kelvin for temperature, degree Celsius is used (the Kelvin scale was derived from the Celsius scale).

PREFIXES

Prefix	Symbol	Pronunciation Symbol	Multiples & Fractions
exa	E	ex´ah	1 000 000 000 000 000 000
peta	P	pet´ah	1 000 000 000 000 000
tera	T	tear´ah	1 000 000 000 000
giga	G	jig´,ah	1 000 000 000
mega	M	meg´ah	1 000 000
kilo	k	kill´oh	1 000
hecto	h	heck´toh	100
deka	da	deck´ah	10
deci	d	dess´ih	0.1
centi	c	cent´ih	0.01
milli	m	mill´ih	0.001
micro	μ	mike´roh	0.000 001
nano	n	nan´oh	0.000 000 001
pico	p	pee´koh	0.000 000 000 001
femto	f	fem´toh	0.000 000 000 000 001
atto	a	att´oh	0.000 000 000 000 000 001

Complete these equations if you can:

1 000 000 lomania = _____

1 000 000 000 ntic = _____

0.000 001 nesia = _____

1 000 000 000 000 tory = _____

0.000 000 000 000 000 001 rney = _____

1 000 000 000 000 000 000 rcist = _____

LESSON 8: SI STYLE CONVENTIONS

Think of it! There is no universal language, there is no universal monetary system. But at last we stand on the threshold of having a universal measurement system, a system understood by people all over the world. To make communication easier, certain style conventions are recommended. This section cites the major conventions.

1. Use a space to separate large numbers into groups of three. Do not use a comma. In many countries a comma is recognized as a decimal point.

Example:	Correct	Incorrect
	600 300.6	600,300.6

2. Use a zero in front of the decimal point when the numerical value is a partial unit.

Example:	Correct	Incorrect
	0.6 mm	.5 mm

3. Use a decimal to express partial units. Avoid using fractions to express partial units.

Example:	Correct	Incorrect
	0.25 kg	1/4 kg

4. Use uppercase or lowercase letters as they are given in the table. All abbreviations or symbols are to be used in the singular form. Do not use periods after symbols unless they conclude a sentence.

Example:	Correct	Incorrect
	mm (millimeters)	mms or mm's
	cg	c.g.
	ℓ	ℓ.

5. Prefixes must be combined with units. In common usage "kilo" means kilogram. Such usage is not preferred.

6. Avoid mixing units.

Example:	Correct	Incorrect
	12.75 m	12 m 75 cm

7. Avoid using multiple prefixes.

Example:	Correct	Incorrect
	ps (picosecond)	μμs (micromicrosecond)

8. Avoid capitalization of unit names (except Celsius) unless they start a sentence. Listings should be lowercase.

Example: Correct - The base unit for mass is the kilogram.

Incorrect - The base unit for mass is the Kilogram.

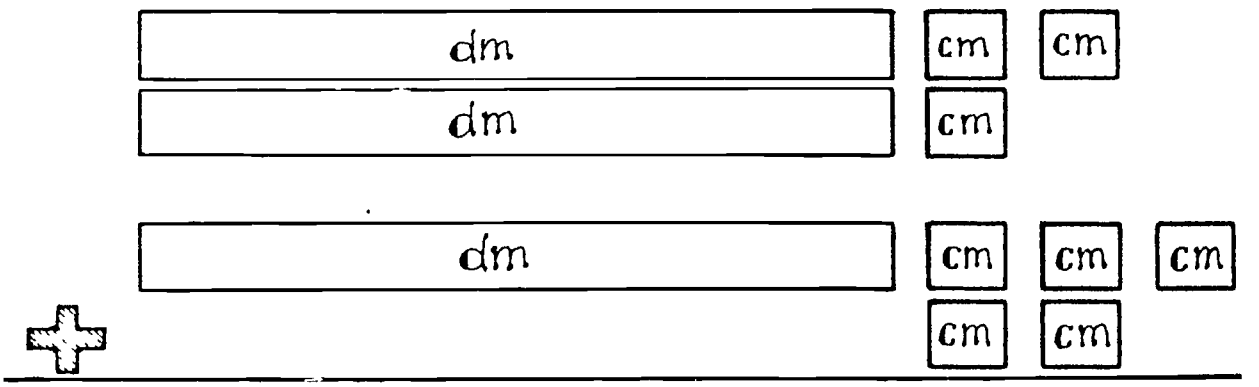
NEXT-TO-LAST-LESSON: DECIMALS

Our number system, our monetary system, and the metric system all share a common characteristic: they are decimal in nature. Because of this, the switch to metric makes the study of decimals even more important than ever. The 4M COMPANY begins the study of decimals in the third grade. The purpose of this lesson is to illustrate how the decimal nature of the metric system is used to teach decimals.

Since a decimeter is one-tenth of a meter, decimeters are used to introduce tenths. Students make a meter strip marked in tenths of meters and use it to measure various lengths.

Similarly, since a centimeter is one-hundredth of a meter, centimeters are used to introduce hundredths. And a millimeter, being one-thousandth of a meter, is used to introduce thousandths.

Addition and subtraction of decimals are explained in terms of metric units. Thus, the problem $\begin{array}{r} 0.23\ \text{m} \\ +0.15\ \text{m} \\ \hline \end{array}$ is represented as follows:



If placed end-to-end, these units would come to the 0.38 m mark on a meter marked in hundredths. Since 10 centimeters can be exchanged for 1 decimeter, borrowing and carrying are easily explained in terms of metric units. The students soon see that adding and subtracting decimals is very similar to adding and subtracting whole numbers.

LAST LESSON: METRIC FOR EVERYDAY LIVING

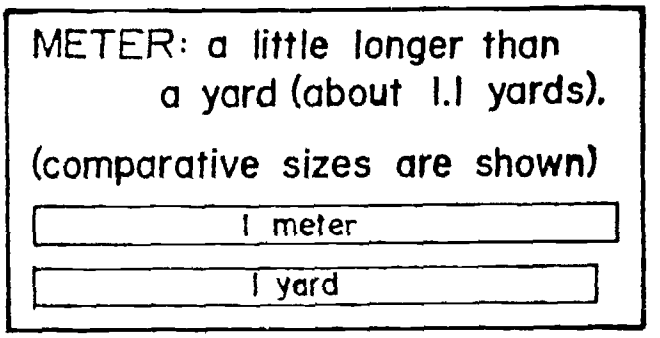
In this section we list those metric units which are most commonly used in everyday living.

Length: 1) A meter is a little longer than a yard.

2) A kilometer (1000 meters) is about 6/10th of a mile.

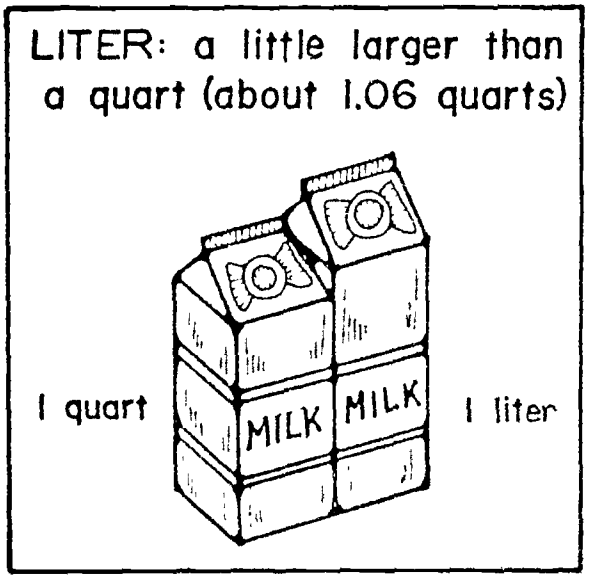
3) A centimeter (0.01 meter) is about the width of a paper clip.

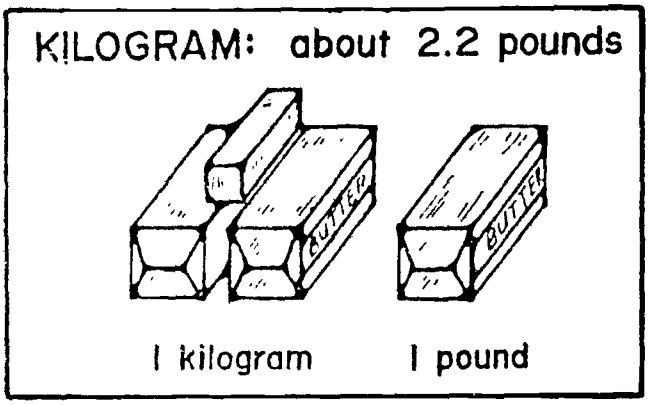
4) A millimeter (0.001 meter) is about the thickness of a dime.



Capacity: 1) A liter is a little larger than a quart (about 1.06 quarts).

2) A milliliter is 1/5th of a teaspoon.





Mass: 1) A gram is the mass of two small thumb tacks.

2) A kilogram is about 2.2 pounds.

3) A metric ton is 2200 pounds.

4) A milligram is the weight of a bee's wing.

ANSWERS TO PROBLEMS

LESSON 3:

hectogram	deciliter
dekaliter	centiliter
kilometer	decigram
milligram	dekagram
hectoliter	dekacards
centigram	deciArnaz
millimeter	centimentalist
centimeter	kilomanjaros
milliliter	millitary
hectoliter	decimate
kiloliter	kilowhats?
kilogram	milliscent
dekameter	centipede
decimeter	

LESSON 7:

megalomania
jigantic
micronesia
teratory
attorney
exarcist